INTERMEDIATE EDUCATION BOARD FOR IRELAND.

RULES AND PROGRAMME OF EXAMINATIONS

FOR 1907.

PRESENTED IN PURSUANCE OF THE INTERMEDIATE EDUCATION (IRELAND) ACT, 1878, *Section* 6.

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Intermediate Education Board for Ireland.

Intermediate Education (Ireland) Acts, 1878 to 1900.

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THE INTERMEDIATE EDUCATION BOARD FOR IRELAND.

OFFICIAL CALENDAR.

I. In reference to the Examinations of June, 1906.

1906. Sept.	15	Earliest day for transmitting schemes for the application of the Preparatory Grade prize fund.
Oct.	1	Latest day for transmitting schemes for the application of the Preparatory Grade prize fund.
Oct.	1	Latest day for transmitting students' statements as to the mode of applying exhibitions.
Oct.	1.	Latest day for transmitting forms of requisitions for marks.
Oct.	15.	Latest day for transmitting claims for school grants, 1906.

II. In reference to the Examinations of June, 1907.

Sept.	15	Earliest day for transmitting applications for examinerships.
Oct.	15.	Latest day for transmitting applications for examinerships.
Nov.	1.	Latest day for transmitting the lists of students on the roll of the school on the preceding 15th October.
Dec.	1.	Latest day for transmitting applications for exemption from Science teaching for the year 1906-7.
1907 Jan.	15	Earliest day for transmitting applications for superintendentships.
Feb.	1.	Earliest day for transmitting applications for forms for choirs.
Feb	15	Latest day for transmitting applications for superintendentships.
Feb.	23	Latest day for making application to the Stamp Distributors and Postmasters authorised to sell Inland Revenue Stamps throughout Ireland. and in Dublin to the Licensed Vendors of Stamps for forms of February Notice and Special Notice for Music.
Feb.	28	Latest day for transmitting students' notices of intention to present themselves for examination (together with satisfactory evidence of age) stamped with an Intermediate Education Stamp of 2*s*. 6*d*.

Feb.	28	Latest day for transmitting students' notices of intention to present themselves for examination in music, stamped with an Intermediate Education Stamp of 10*s*. 6*d*.
Feb.	28.	Latest day for transmitting managers' lists of students intending to present themselves for examination in music and notices of intention to present choirs or orchestras for examination and for the special competition in Dublin.
March	31.	Latest day for transmitting students' notices of intention to present themselves for examination (together with satisfactory evidence of age) stamped with an Intermediate Education Stamp of 10*s*.
March	31	Latest day for transmitting completed forms for candidates for Burke Memorial Prizes.
April	15.	Earliest day for making application for the prescribed forms of managers' declarations and private students' declarations as to students having pursued a course of study in Ireland.
May	1.	Earliest day for transmitting managers' declarations and private students' declarations as to students having pursued a course of study in Ireland.
May	21.	Latest day for transmitting managers' declarations and private students' declarations as to students having pursued a course of study in Ireland.
Sept.	15.	Earliest day for transmitting schemes for the application of the Preparatory Grade prize fund.
Oct.	1.	Latest day for transmitting schemes for the application of the Preparatory Grade prize fund.
Oct.	1.	Latest day for transmitting students' statements as to the mode of applying exhibitions.
Oct.	1.	Latest day for transmitting forms of requisitions for marks.
Oct	15	Latest day for transmitting claims for school grant, 1907.

III. IN REFERENCE TO THE EXAMINATIONS OF JUNE, 1908.

Nov.	1.	Latest day for transmitting the lists of students on the roll of the school on the preceding 15th October.
Dec.	1.	Latest day for transmitting applications for exemption from Science teaching for the year 1907-8.

NOTE.—"Transmit" means to send by post or otherwise, so as to reach the office within office hours on the day named in the rule, or on the following day if the day named be a Sunday (Rule 102).

Intermediate Education Board for Ireland.

RULES.

The Intermediate Education Board for Ireland, in pursuance and by virtue of the "Intermediate Education (Ireland) Acts, 1878 to 1900," do hereby, with the approval of His Excellency John Campbell, Earl of Aberdeen, Lord Lieutenant General and General Governor of Ireland, make the following Rules for the purposes of the said Acts:—

SECTION I.

General Provisions regarding the examinations.

1. Except in the practical portion of the examination in music and in experimental science, examinations in accordance with the following rules will be held in each year, between the first day of June and the first day of August at convenient centres, which will be selected by the Board with the approval of the Lord Lieutenant.

2. Except in the practical portion of the examination in music and in experimental science, all the examinations are conducted by printed papers, unless when otherwise directed in programme. **Examinations by printed papers.**

3. Public notice will be given by the Board of the times at which the written examinations will be held.

4. There will be four Grades, viz. :—Preparatory, Junior, Middle and Senior. **Grades.**

(A) In the Preparatory Grade there will be no honours, medals or exhibitions.

(B) In each of the other Grades—Junior, Middle and Senior—there will be four distinct Courses for Exhibitions and Prizes, viz. :— **Courses for Exhibitions and Prizes.**

(i.) the Classical Course;

(ii.) the Modern Literary Course; Division I.
Division II.

(iii.) the Mathematical Course;

(iv.) the Experimental Science Course.

Examination of girls.

5. The examination of girls will be held apart from that of boys, except when otherwise ordered by the Board.

Subjects in which a pass may be obtained.

6. The following are the subjects in which a pass may be obtained in all grades :—

The ancient language, literature, and history of **Greece**;
The ancient language, literature, and history of **Rome**;
English Literature and **Composition**;
History and **Geography**;
The **French** language;
The **German** language;
The **Irish** language;
The **Italian** language;
The **Spanish** language;
Arithmetic;
Algebra;
Geometry;
Experimental Science;
Music.

Together with the following for particular grades :—
Shorthand, Junior, Middle and Senior Grades;
Book-keeping, Junior, Middle and Senior Grades;
Natural Philosophy, Middle and Senior Grades;
Trigonometry, Middle and Senior Grades.

Subjects in which honours may be obtained.

7. The following are the subjects in which honours may be obtained in the Junior, Middle and Senior Grades :—

The ancient language, literature, and history of **Greece**;
The ancient language, literature, and history of **Rome**;
History and **Geography**;
The **French** language;
The **German** language;
The **Irish** language;
The **Italian** language;
The **Spanish** language;
Geometry;
Algebra;
Experimental Science.
Together with **Trigonometry** for Middle and Senior Grades only.

8. The Programme of the examinations in the several subjects of examination is set forth in the Schedule hereto.

SECTION II.

Special Regulations as to Experimental Science.

9. (*a*) The courses included under the title of experimental science and the order in which they are to be taken, are as follows:— Order of subjects.

Preliminary Course.

For the first year:—

Experimental Science and Drawing (First Year Syllabus).

For the second year:—

Experimental Science and Drawing (Second Year Syllabus).

Special Courses.

For the third year:—

Physics,
Chemistry,
Mechanics,
Botany,
Domestic Economy,
Physiology and Hygiene,
Drawing.

For the fourth year:—

Physics,
Chemistry,
Mechanics,
Botany,
Domestic Economy,
Physiology and Hygiene,
Geology,
Drawing.

(*b*) To pass in experimental science, a student must be certified by the Department to have fulfilled the following conditions:— Conditions of pass

(1.) To have followed the prescribed course of instruction in a school approved by the Department (see (*d*) *infra*).

(2.) To have been registered on the Department's forms as having been in attendance at instruction in each of the prescribed subjects of the course on or before the 1st day of November.

(3.) To have received during the session:—

In a Preliminary Course at least one hundred hours' instruction, including at least sixty hours' instruction in Science, and at least twenty hours' instruction in Drawing, or in a Special Course, at least seventy-five hours' instruction,

(4.) To have worked through the prescribed course to the satisfaction of the Department's Inspector, who may test the student in such a manner as he may deem necessary.

Honours. (c) To pass with honours, a student must fulfil the following conditions :—

(1.) Satisfy the requirements for a pass in the course or courses in which he presents himself

(2.) Pass in the same course or courses a qualifying practical test by an Inspector of the Department.

(3.) Obtain not less than 50 per cent. on the examination paper in the course or courses.

Conditions of approval of Schools. (d) To be approved by the Department a school must satisfy the following conditions ;—

(1.) The accommodation and equipment must be adequate.

(2.) The instruction in the courses in experimental science must be under teachers whose qualifications have been recognised in writing by the Department.

(3.) The time table of the course of instruction in the courses in experimental science must be approved by the Department: the course must be continuous throughout the session.

(4.) The instruction given must be of a class superior to that given in elementary schools.

(e) Passes in one or more of the special courses will count as passes in one or more *subjects* for the purposes of Section IX.

(f) A student may not take one of the courses for the third or fourth year in the same year with either the course for the first year or for the second year; but a student taking any fourth year course in the prescribed order, may, in the same year, take any course for the third year in which he has not already passed.

Repetition. (g) A student may obtain a pass or honours in a course of any year not more than twice. No student can obtain a pass or honours in any course lower than that in which he has already passed.

SECTION III.

Compulsory Preliminary Course in Experimental Science.

Compulsory preliminary Courses. 10. The two years' preliminary course of Experimental Science will be compulsory on all students whose names are on the roll of an Intermediate school except—

(a) Students who present themselves for examination in both Greek and Latin, and obtain at least 20 per cent. of the maximum marks in each of these subjects ;

(b) girls passing under the conditions of Rule 35.

Exemption.

11. Exemptions may be granted from the compulsory courses in experimental science in the case of schools which shall satisfy the Board that they are unable to provide the necessary equipment or teaching staff, or to obtain instruction for their pupils in a laboratory approved by the Department. Applications for exemption should be made on the prescribed form, and should be transmitted to the Board not later than the first day of December in the educational year for which exemption is sought.

Copies of the prescribed form may be obtained on application to the Assistant Commissioners.

SECTION IV.

Special Regulations for the examination in Music.

Two parts of examination in music.

12. (*a*) The examination will include both theory and practice. The programmes in theory for the various Grades are contained in the Programme for Music :—

For the Preparatory Grade, No. 7 of the Programme of that Grade.
,, ,, Junior ,, No. 8 ,, ,, ,,
,, ,, Middle ,, No. 8 ,, ,, ,,
,, ,, Senior ,, No. 8 ,, ,, ,,

Relation between two parts of examination

(*b*) No student who has not been certified by the examiner to have passed the practical examination will be admitted to the examination in theory. The maximum of marks assigned to the practical test, will bear to the maximum of marks assigned to the examination in theory the proportion of five to three.

Latitude allowed in selecting Grades.

(*c*) Students presenting themselves in any grade above the Preparatory for examination in the theory of music may present themselves in the programme of the practical examinations of either Junior, Middle or Senior Grade, that is, such students may take the course for any Grade above the Preparatory for the practical test, but for the theoretical examination they must take the course prescribed for the Grade in which they present themselves for the general examination.

Conditions of a Pass.

(*d*) No student will be adjudged to have passed in music who has not obtained at least 30 per cent. of the marks assigned to the practical part, and 30 per cent. of the marks assigned to the theoretical part of the examination.

(*e*) In the practical test the examiners may question the students as to their general knowledge of music.

(*f*) In all cases scales and arpeggios must be played from memory. and as quickly as is consistent with accuracy.

(*g*) In the practical test no person except the student under examination shall be allowed in the room with the examiners.

(*h*) Students will receive, in due course, special admission cards for the practical test, fixing the time and place of examination. These cards must be signed by the student before presenting them to the Examiners.

(*i*) Students entering for the practical examination in music may present for more than one instrument; an additional fee, 10s. 6d. (see Rule 16), to be paid for each additional instrument, except in the case of instruments of the same kind, viz.: violin, viola, violoncello, double bass.

SECTION V.

Students not eligible for examination.

Students ineligible for examination in any Grade.

13. A student will be ineligible for examination in any Grade :—

(*a*) whose age on the first day of June preceding the examination is under 13 or over 19 years;

(*b*) who has not pursued a course of study in Ireland for the full period of the educational year preceding the date of examination;

(*c*) who is a matriculated student of a university.

For the purpose of these rules a student whose birthday occurs on 1st June may be deemed to be under the age which he completes on that day.

Students ineligible for examination in particular Grades.

14. A student will be ineligible for examination :—

(*a*) in a Grade lower than one in which he has formerly passed;

(*b*) in a Grade in which he has already twice passed;

(*c*) in a Grade in which he obtained an exhibition of the highest class;

(*d*) in the Preparatory Grade if his age on the first day of June preceding the examination is over 15 years.

SECTION VI.

Notices and declarations to be sent in by students, and by managers, and other matters preliminary to the examinations.

Student's February Notice. 2s. 6d. Stamp. 10s. stamp.

15. Students intending to present themselves for examination shall transmit to the Board, in the prescribed form,* notice of their intention, together with satisfactory evidence of age. Such notice shall specify the grade and the subjects in which, and the centre at which, the student proposes to present himself; and shall be stamped with an Intermediate Education stamp of 2*s.* 6*d.*, if such notice together with the evidence of age be transmitted to the Board not later than the last day of February, and with a stamp of 10*s.*, if such notice or evidence be transmitted after that day, and not later than the 31st day of March. If such notice or evidence be transmitted after the 31st day of March, the student will not be allowed to present himself for examination. The examination of the student will be confined to the subjects specified in his notice.

Music.

16. Students intending to present themselves for examination in music shall transmit to the Board, in addition to the notice under Rule 15, special notice of such intention in the prescribed form,* stamped with an Intermediate Education stamp of 10*s.* 6*d.*, to be transmitted to the Board not later than the last day of February.

Music Lists

17. Each manager of a school shall transmit to the Board, not later than the last day of February, a list, on the prescribed form, of the names of the students attending his school who intend to present themselves for examination in music in accordance with the Notice prescribed under Rule 16. Copies of the prescribed forms may be obtained on application to the Assistant Commissioners not earlier than the 1st February.

Evidence of Age.

18. The Board will accept as satisfactory evidence of age a certified extract from a public registry of births, or if such certified extract cannot be obtained, a statutory declaration from a parent or

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* These forms can be obtained *only* from the several Stamp Distributors and Postmasters authorized to sell Inland Revenue Stamps throughout Ireland, and in Dublin from the Licensed Vendors of Stamps; *they are not procurable at the Office, 1 Hume street.*

Application for the forms bearing the 2s. 6d. stamp, and the 10s. 6d. stamp should be made not later than 23rd February and for the forms bearing the 10s. stamp, not later than the 26th March.

guardian of such student, stating, in the prescribed form, the date of birth, and also specifying:—

(*a*) declarant's means of knowing of the date of birth as so stated, and

(*b*) the reasons on account of which a certified extract from a public registry of births cannot be obtained.

The following will not be accepted as evidence of age:—

(*a*) Baptismal Certificates.
(*b*) Certificates of Registry of Birth.
(*c*) Certified extracts from public registries of birth issued under
  (1) The Factory and Workshop Act, 1901;
  (2) The Irish Education Act, 1892;
  (3) The Friendly Societies' Act, 1896.

Burke Memorial Prizes.

19. Subject to the exception in the next following rule a candidate for a Burke Memorial prize shall, not later than the 31st March, transmit to the Board, in the prescribed form, the further particulars necessary to show that he is entitled to compete. Copies of the prescribed form may be obtained on application to the Assistant Commissioners.

20. A candidate for the said prize whose father becomes entitled after the 31st March to such salary or pension as qualifies his children to compete for this prize may transmit these particulars at any time previous to the first day of the examinations.

Examination No.

21. Each student will be assigned a number by which alone he shall be known in the subsequent written examination.

Admission Card.

22. No student will be admitted to the examination without an admission card.

Such admission card will not be issued to anyone unless the declaration as to a course of study has been received as prescribed by Rules 23 or 24.

May Declaration for Schools.

23. Each manager who intends to claim a school grant, shall, on or after the 1st, and not later than the 21st, day of May, transmit to the Board a declaration, in the prescribed form, signed by him, stating the names of the students upon the roll of his school who have pursued their studies in his school during the educational year then current, and the subjects, if any, of those specified in their February notices under Rule 15, in which they propose to present themselves for honours and in the case of each candidate for an exhibition or prize, the course and the two main subjects thereof in which he elects to be examined.

Candidates for exhibitions may not select more than one course in which they will present themselves for examination.

Copies of the prescribed form may be obtained on application to the Assistant Commissioners not earlier than 15th April.

May Declaration for students not on a school roll.

24. A student whose name is not on the roll of an Intermediate school, or whose name is not included in the declaration of a manager under the last preceding rule, shall on or after the 1st of May and not later than the 21st of May, transmit to the Board, in the prescribed form, a declaration to the effect mentioned in such rule, made by himself, and certified as correct by his parent or guadian.

Copies of the prescribed form may be obtained on application to the Assistant Commissioners not earlier than 15th April.

25. In all subjects in which pass and honour papers are set, both papers will be distributed simultaneously, but each student will receive only one paper in accordance with the notice given under Rules 15, 23 and 24.

SECTION VII.

Conduct of students during the examination.

26. When presenting himself for examination in geometry each student shall bring with him a ruler graduated in inches and centimetres and their usual sub-divisions, compasses, and set squares.

Rules for direction of students.

27. A student shall not bring into the examination room, or have in his possession, or under his control, or within reach, during the examination :—

(*a*) any book or paper (save his admission card, the examination paper, and such answer books as shall have been supplied to him by the superintendent) ; or

(*b*) any slate, memorandum or notes.

28. A student shall not, while in the examination room :—

(*a*) use, or attempt to use, any book, memorandum, notes, or paper (save the examination paper, and such answer books as shall have been supplied to him by the superintendent) ;

(*b*) aid, or attempt to aid, another student ;

(c) obtain, or attempt to obtain, aid from another student;

(d) communicate, or attempt to communicate, in any way with another student.

Any student found by the superintendent violating this rule or Rule 26 will be expelled from the examination room, and will not be permitted to return to it during the continuance of the examination in the subject in which the examination papers shall have been then distributed.

29. A student

(a) shall not write on the examination paper;

(b) shall not remove from the answer books, any leaf, or part of a leaf;

(c) shall not take out, or attempt to take out, of the examination room, any answer books, whether used or unused;

(d) shall not damage the examination room or its furniture;

(e) shall, immediately after he has concluded his answers, deliver his answer books, whether used or unused, enclosed in an envelope endorsed with his examination number, and also his examination paper (except at the close of the period allotted for the examination) to the superintendent, and shall then leave the examination room; and

(f) shall, in all matters relative to the examination, submit to, and obey, the directions of the superintendent.

Penalty for Violation of Rules. 30. Any student adjudged by the Board to have violated any of the Rules 27, 28, or 29 will be liable to be deprived of all credit for the examination or of marks, or to have such deduction made, as the Board may think fit, from any sum payable in respect of any prize or exhibition obtained by him, according to the judgment the Board may form of the gravity of the offence; and the Board may, if they think fit, publish his name and address, as given in his notice of intention to present himself for examination, as those of a student who has been so deprived.

SECTION VIII.

Conditions of passing the examination in particular subjects.

31. No student will be adjudged to have passed the examination in any subject, except those specified in Rules 9 and 12, who has not obtained:— Pass

(1) 30 per cent. on the pass paper in any subject; or

(2) 20 per cent. on the honour paper in any mathematical subject; or

(3) 25 per cent. on the honour paper in any other subject.

32. No student will be adjudged to have passed in Greek, Latin, French, German, Irish, Italian, or Spanish, who has not obtained at least 20 per cent. of the marks assigned in any of these languages to translation from English into that language. Special condition for languages

33. No student will be adjudged to have passed in English Literature and Composition, who has not obtained at least 30 per cent. in English Literature and 30 per cent. in Composition.

SECTION IX.

Conditions of passing the examination generally.

34. In all the Grades, students may present themselves in any number of subjects, but, except as provided in Rules 35 and 36, to pass the examination they must pass in the subjects as set forth for the several Grades in the following scheme:—

PREPARATORY GRADE.

(A)—English Literature and Composition.

(B)—One of the following subjects:—
(1) Latin, (2) French, (3) German, (4) Irish.

(C)—Arithmetic or Algebra.

(D)—Experimental Science.

(E)—One other subject.

JUNIOR, MIDDLE AND SENIOR GRADES.

(A)—English Literature and Composition.

(B)—One or two of the following languages:—(1) Greek, (2) Latin, (3) French, (4) German, (5) Irish, (6) Italian, (7) Spanish. If only one language is taken, it must be either Latin, French, or German,

(C)—One of the following Mathematical Subjects:—(1) Arithmetic, (2) Algebra, (3) Geometry, (4) Trigonometry.

(D)—Experimental Science. (See note).

(E)—One or two other subjects, according as may be necessary to bring the total number of subjects up to six.

NOTE.—Students are exempted from the obligation of taking Experimental Science who have already obtained a pass in the two years of the Preliminary Course in this subject. Exemptions from Experimental Science may be granted under Rules 10 and 11, *supra*. No student is required to take this subject whose name is not on the roll of an Intermediate school. In all cases, students not taking Experimental Science must take either two languages under (B), or two Mathematical subjects under (C).

Special Provision Pass Examination, Girls.

35. In the Junior, Middle and Senior Grades, girls may present themselves for examination in English Literature and Composition, and in the honour papers of any three other subjects of the Programme. They will be deemed to have passed the examination if:—

(*a*) they pass in English Literature and Composition;

(*b*) obtain honours in at least one of three honour subjects; and

(*c*) obtain in any of such subjects in which they do not obtain honours the percentage stated in Rule 31,(2) & (3).

Principle of Average.

36. If a student obtain less than 30 per cent. in any one of the subjects prescribed, but not less than 25 per cent., he shall be adjudged to have passed the examination generally, provided the aggregate of his marks in all the subjects is equivalent to an average of 30 per cent. in each.

If a student take honour papers in any subject, the marks obtained will be increased, for the purpose of a pass, by 50 per cent. in the case of mathematical papers, and 20 per cent. in the case of other papers.

For the purpose of this Rule a student who obtains a pass in Experimental Science shall be deemed to have obtained 30 per cent. in that subject.

SECTION X.

Honours, medals, exhibitions, and prizes.

Honours. 37. To obtain honours in any honour subject, students must obtain 50 per cent. on the honour paper in that subject, except in the mathematical subjects in which 35 per cent. will be sufficient.

38. No student will be awarded honours in Greek, Latin, French, German, Irish, Italian, or Spanish, who shall not have obtained at least 40 per cent. of the marks assigned in any of these languages to translation from English into that language.

Pass with Honours. 39. A student will be adjudged to have passed the examination with honours who has passed the examination generally, and has obtained honours in at least three subjects.

Exhibitions. 40. Exhibitions, tenable for one year, the highest of which will not exceed in value the following sums, viz.:—in the Junior Grade £15, in the Middle Grade £25 and in the Senior Grade £40, will be awarded in each Course to such students in the Junior, Middle, and Senior Grades respectively, as the Board shall adjudge to have passed with honours and to have obtained the highest totals of honour marks, subject to the provisions of Rules 42 and 44.

Prizes. 41. Prizes, in books, philosophical apparatus, or other objects useful for educational purposes, of the respective values of £3, £2, and £1, may be awarded to students in accordance with the provisions of Rule 49.

Marks counting for exhibitions. 42. Marks on the honour paper in not more than four subjects, in addition to the excess of marks above 50 per cent. obtained in English Literature and Composition, will count towards exhibitions. The marks counted towards exhibitions will be, in each subject, the excess of marks obtained above the standard necessary to obtain a pass in the honour paper of that subject, and in experimental science, the excess of marks above 25 per cent.

Courses for exhibitions. 43. Exhibitions and prizes can be obtained in any one of the following courses:—

I. the Classical Course;
II. the Modern Literary Course;
III. the Mathematical Course;
IV. the Experimental Science Course.

To be eligible for exhibitions in any Course students must pass the examination generally and obtain honours in three subjects, two of which, hereinafter called the *main subjects*, must be as follows :—

(I.) in the Classical Course, in Greek and Latin.

(II.) in the Modern Literary Course :
Division I. in either French or German and in Irish.
Division II. in French and German.

(III.) in the Mathematical Course, in the Junior and Middle Grades in :—
(1) Algebra ; and
(2) Geometry,
and in the Senior Grade in
(1) Algebra ; and
(2) Geometry or trigonometry.

(IV.) in the Experimental Science Course in :—
(1.) (*a*) one of the Preliminary Courses of Experimental Science and Drawing, *or*
(*b*) a special course in Physics, Chemistry or Mechanics, or Botany (for girls).
(2.) One of the following subjects:—(*a*) Algebra; (*b*) Geometry; (*c*) Trigonometry for Senior Grade only.

Special Paper for exhibitions, prizes, and medals.

44. In addition to the general honours examination candidates for exhibitions, prizes and medals will be further examined in a more searching paper in each of the *main subjects* of the course selected by them, and the marks for this special paper will be the same as for the corresponding honour paper. The marks gained by the candidate on such special paper, computed as provided by Rule 42, will be added to those gained on the honour paper in the same subject.

Students ineligible by age for prizes and exhibitions.

45. A student will be ineligible for prizes, medals, or exhibitions whose age on first day of June preceding the examination shall exceed :—

16 years	in the case of	Junior Grade	students.
17 ,,	,,	Middle Grade	,,
18 ,,	,,	Senior Grade	,,

46. Any student who is a candidate for an exhibition in a grade in which he has already been awarded an exhibition will not be eligible for an exhibition unless it be of a higher class than that previously awarded.

Number of exhibitions

47. Exhibitions and prizes in each Grade and Course will be allocated on the basis of a *Standard Mark* which shall be the average of marks, counting towards an exhibition, obtained by the first five students in each Course of each Grade, respectively.

Exhibitions to Boys.

48. Exhibitions will be awarded, in each Course of each Grade, to boys whose marks, counting towards an exhibition, do not fall below 75 per cent. of the standard mark of the Course in which they compete; provided always, that the number of exhibitions awarded shall not, in any case, be more than one-half, or less than one-fourth, of the number of students who have qualified for exhibitions and prizes in the same Course and Grade.

Prizes to Boys

49. In like manner prizes will be awarded in each Course of each Grade, to boys who fail to get an exhibition, and whose marks, counting towards an exhibition, do not fall below 60 per cent. of the standard mark of the Course in which they compete; provided always, that the number of prizes awarded shall not, in any case, be more than one-half, or less than one-fourth, of the number of students who have qualified for exhibitions and prizes in the same Course and Grade.

Exhibitions and Prizes to Girls.

50. Rules 47, 48 and 49, both as regards exhibitions and prizes, will hold for girls in the Courses of Modern Literature and Experimental Science. In the other two Courses, every girl will be awarded an exhibition whose marks, counting towards an exhibition, do not fall below 70 per cent. of the standard mark for boys in the same Course and Grade; and every girl, failing to obtain an exhibition, will be awarded a prize, if her marks, counting towards an exhibition, do not fall below 50 per cent. of the standard mark for boys in the same Course and Grade.

Classification of Exhibitions and Prizes

51 The exhibitions and prizes will each be divided into three classes as follows:—

The limiting mark of first class exhibitions will be 95 per cent. of the standard mark. The limiting mark of second class exhibitions will be 85 per cent. of the standard mark. The remainder will be third class exhibitions.

For boys in all Courses, and for girls in the Modern Literary and Experimental Science Courses, the limiting mark of first class prizes will be 70 per cent. of the standard mark. The limiting mark of second class prizes will be 65 per cent. of the standard mark. The remainder will be third class prizes.

For girls in the Classical and Mathematical Courses, the limiting mark of first class prizes will be 65 per cent. of the standard mark for the corresponding course and grade for boys. The limiting mark of second class prizes will be 60 per cent. of the standard mark for the corresponding course and grade for boys. The remainder will be third class prizes.

Exhibitions may be applied to provide for education of student in a school.

52. The Board may direct that the payments in respect of any exhibitions in the Junior and Middle Grades shall be subject to the condition that the amount shall be applied to provide for the future education of the student in a school to be selected by the parent or guardian of the student, subject to the approval of the Board, and the amount of the exhibition shall be paid to the manager of such school and shall be applied for the education, maintenance, expenses of attending school, or otherwise for the benefit, of the student, upon such terms as shall be agreed upon between the parent or guardian and the manager, subject to the approval of the Board. Every agreement under this rule shall be on the prescribed form, and shall be lodged with the Board within such time as may be prescribed.

Exhibitions may be applied by the Board for the benefit of student.

53. The Board may direct that the amount of any exhibition in the Junior, Middle, or Senior Grade, instead of being paid to the student, or applied in the manner prescribed by the preceding rule, shall be applied in or towards the payment of any sums due to the manager of a school for the student's education or maintenance as a pupil at a school during the educational year in which the exhibition was obtained, or in or towards the payment of the cost of obtaining further or more advanced or special education or instruction, or in or toward the payment of fees, premiums, or expenses required for enabling the student to prepare or qualify for a suitable calling or employment, or otherwise for his permanent benefit and advancement in life.

Statement of intention.

54. A student who has obtained an exhibition shall before the 1st day of the following October transmit to the Board a statement of the mode within either of the two last preceding rules in which he may desire the amount of his exhibition to be applied in the event of the Board determining that the same shall not be paid to him directly.

Such statement shall be in the prescribed form and shall be signed by the student and his parent or guardian.

Certificates, undertakings, &c. from managers, parents, &c.

55. In order to satisfy themselves that the payments in respect of exhibitions are or shall be applied in accordance with the purposes of the preceding rules, the Board may call for such certificates, undertakings, or declarations, from managers of schools, teachers, employers, parents, or others, or for such other evidence as the Board may in each case think necessary or sufficient; and may retain the amount of any exhibition pending the production of such evidence, and in any case in which the Board shall not be so satisfied before the student attains the age of nineteen years, the right to receive payment of the exhibition will cease, unless the Board shall otherwise direct.

Medals. 56. In case distinguished merit has been shown, bronze medals may be awarded to students in the Junior, Middle and Senior Grades respectively, who have passed the examination generally, and have, in addition, obtained the highest honour marks on the honour paper, or in the case of those subjects in which there is the special paper mentioned in Rule 44, the highest total honour marks obtained on such special paper and the corresponding honour paper, viz. :—

1. in Greek ;
2. in Latin :
3. in English literature and composition ;
4. in history and geography ;
5. in each modern language ;
6. in geometry ;
7. in algebra ;
8. in trigonometry ;
9. in experimental science.

Case of equality of marks. 57. A larger number of medals may be awarded it two or more students obtain equal marks.

58. A student cannot obtain a medal a second time for the same subject, in the same Grade.

SECTION XI.

Special Prizes.

Prizes for Composition. 59. Provided sufficient merit be shown, prizes in books, philosophical apparatus, or other objects useful for educational purposes may be awarded to students in the Junior, Middle, and Senior Grades, who have passed the examination, and have obtained the highest marks in English composition, or in translation of English into any of the following languages :—

Greek, Latin, French, German, Irish, Italian, or Spanish,

Such prizes will be of the value of :—

£4 each, in the Senior Grade ;
£3 in the Middle Grade ; and
£2 in the Junior Grade.

Prizes to be subject to approval of Board. 60. All books, philosophical instruments, or other objects useful for educational purposes, which may be selected as prizes, are subject to the approval of the Board.

Special Prizes in Greek and German. 61. In Greek and in German, prizes may be awarded to students who have passed the examination and have obtained the highest marks in these subjects. Such prizes shall not exceed the value of :—

£10 each in the Senior Grade ;
£7 each in the Middle Grade ;
£5 each in the Junior Grade ;
£3 each in the Preparatory Grade.

Preparatory Grade Prize Fund. 62. The Board have power to assign to such managers of schools as shall, before the 1st October, have submitted schemes in respect thereof to the Board, a sum of money calculated at a rate not exceeding £1 per pass in the Preparatory Grade, as a prize fund for that Grade, to be applied according to such schemes as shall have been sanctioned or altered by the Board.

SECTION XII.

Certificates.

Certificates of passing generally. 63. Certificates will be issued to all students who have passed the examination ; such certificates will specify the subjects in which the students have passed, or have obtained honours.

Certificates for Music. 64. "Pass" Certificates and Certificates of a "Pass with distinction" will be issued on application to successful students at the examination in music, provided they have passed the general examination. To obtain the Certificate of a "Pass with distinction" marked proficiency must be shown, and students must present for the practical examination a programme not lower than that of the Grade in which they enter for the general examination.

No student will be awarded a certificate of a "Pass with distinction" who has not obtained at least 50 per cent. of the marks for the practical test and 50 per cent. of the marks for theory.

SECTION XIII.

School Grant.

Conditions to be observed by managers of schools. 65. The school grant will be paid to managers of schools who, in addition to observing the other rules of the Board, shall have complied with the following conditions, viz. :—

Inspection. (a) Each manager of a school shall, when required by the Board, sign a consent, in the prescribed form, to have his school inspected, and shall permit his school to be inspected accordingly, and shall furnish to the Board or its inspectors the information which the Board shall deem needful for carrying out this inspection.

(*b*) He shall comply with the requirements of the Board as to the provision for health, recreation, sanitation, and physical exercise which the Board may judge necessary.

Lists of Students. (*c*) He shall, not later than the 1st day of November next preceding the examinations, transmit to the Board a list, in duplicate, in the prescribed form,* of all the pupils, within the prescribed limits of age, who were on the roll of such school on the previous 15th of October.

May Declaration. (*d*) He shall, within the appointed time, sign the declaration prescribed by Rule 23, in the case of each pupil in respect of whom he intends to claim the school grant.

Claim before 15th October (*e*) He shall, not later than the 15th day of October next after the examinations in respect of which the school grant may be claimed, transmit to the Board his claim, in duplicate, for such grant in the prescribed form.*

In respect of whom the School Grant payable. 66. The pupils in respect of whom the school grant shall be payable will be those only who shall have fulfilled the following conditions, viz.:—

Name on List. (1) whose names appear on the list transmitted to the Board under Rule 65 (*c*) of the pupils who were on the roll of the school on the preceding 15th day of October;

100 Attendances. (2) who have attended such school from the said 15th day of October, and shall each have made at least one hundred attendances at that school during the period from that date to the 31st day of May following, not more than one attendance being counted for each day.

School Grant. 67. The school grant will consist of (*a*) the normal school grant, and (*b*) the bonus school grant.

(*a*) *The Normal School Grant.*

(1) A capitation grant will be made to the manager of every school for each student subject to the preceding rule who has passed the examination. The amount of this capitation grant will depend on the Grade and will be in such proportion for the several Grades respectively as the Board may decide.

(2) The capitation grant will be increased in the case of honour students by such a percentage as the Board may decide.

(3) The capitation grant, so computed, will be called the normal school grant.

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* Copies of the prescribed form may be obtained on application to the Assistant Commissioners, not earlier than 1st October.

(*b*) *The Bonus School Grant.*

If upon the reports of the inspectors, and considering all the circumstances of the case, the Board shall be of opinion that the education in a school is of a highly satisfactory character, they may increase the normal school grant payable in respect of such school by a sum not exceeding 20 per cent. thereof, and if they are of opinion that such education although not highly satisfactory is yet satisfactory, by a sum not exceeding 10 per cent. thereof.

SECTION XIV.

Bonus for Choirs and Orchestras.

Bonus.

68. With a view to encourage Choral Singing and Orchestral Music in Intermediate schools, the Board shall have power to grant a bonus to the schools which present for examination a choir or orchestra which shall acquit itself to the satisfaction of the examiners.

Ages for choirs and orchestras.

69. Such choir or orchestra must be composed exclusively of pupils actually attending the school, but may contain up to 70 per cent. of students under thirteen years of age. The number in a choir must include not less than 30 per cent. of the total number of pupils whose ages on the first day of June preceding the general examination are between 10 and 19 years, and who have made at least 100 school attendances during the educational year. Students over the age of 19 years and under 10 years, provided they have made at least 100 school attendances (not merely for instruction in Music), may be entered in choirs or orchestras, but may not count in the calculation of the bonus.

Students in respect of whom bonus is payable.

70. In the calculation of the bonus for choirs and orchestras account will be taken only of those students whose names appear on the prescribed February Forms for choirs and orchestras, and who have been present at the examination.

Maximum bonus.

71. The total bonus payable to a school for choir-singing or orchestral music, exclusive of any special prize which may be granted in the case of the special competition in Dublin of choirs and orchestras, may not exceed £80 in any case.

Pieces to be performed.

72. The examination of choirs and orchestras shall include the performance of a piece or pieces selected by themselves, and also an easy piece selected by the examiners, to be performed without previous preparation. In the case of choirs the words of this piece are to be sung.

73. The sight-test will be in the same number of parts as those in which the choirs propose to perform the pieces selected by themselves.

74. All choir-singing is to be unaccompanied by any instrument.

75. In choir-singing and orchestral music the examiners may question the students as to their general knowledge of music.

Notice.

76. Managers of schools who desire to present a choir or orchestra for examination shall give notice of their intention in the prescribed form, and submit the names of the pupils composing such choir or orchestra, with a programme of the music they intend to perform, the parts in which the pieces will be performed by the choir, and the system of notation adopted. Copies of the prescribed form may be obtained on application to the Assistant Commissioners not earlier than the 1st February.

The prescribed forms, together with a fee (by Postal or Post Office Order, or cheque) of £1 1s. for each choir or orchestra, and the Statutory Declaration as to age under Rule 78, shall be transmitted to the Board not later than the last day of February.

77. A school may present more than one choir or orchestra, but the total bonus payable shall not in any case exceed the maximum of £80, for choir singing or orchestral music, as stated in Rule 71. A fee of £1 1s. will be required for each choir and each orchestra.

Evidence of age for choirs and orchestras.

78. In the case of students not entered for the general examination, the Board, for the purpose of a choir or orchestra, may accept as evidence of age a statutory declaration as to age, on the prescribed form to be obtained from the office. One general statutory declaration made by the manager of the school will suffice for all such students in any one choir or orchestra. This declaration is to be transmitted to the office together with the prescribed February Forms (Rule 76) not later than the last day of February.

Applications for these Declaration Forms must give the number of students for whom the form is required, and must be accompanied by a Postal or Post Office Order (made payable to the Assistant Commissioners) for the Stamp Duty of 2*s.* 6*d.*, payable on each form. Postage stamps or cheques will not be accepted.

79. Managers of schools shall check the lists of names of the members of choirs and orchestras as presented by the examiners on the occasion of their visit. Those who are present at the examination, and those who are absent therefrom shall be duly noted on the lists, and the lists shall then be signed by the Manager.

Special Competition in Dublin.

80. The Board shall have power to hold in Dublin a Special Competition for choirs and orchestras of Intermediate schools, at which special prizes will be awarded. The date of this Competition will be announced in due course.

Notice for special Competition. 81. Managers of schools desiring to present a choir or orchestra for the Special Competition shall give notice of their intention on the prescribed form, and submit the names of the pupils composing such choir or orchestra, with a programme of the music they intend to perform, the parts in which the pieces will be performed by the choir, and the system of notation adopted.

Fee for special Competition. 82. The prescribed forms, together with a fee of £1 1*s*. each for choir and orchestra (in addition to the fee for ordinary examination), shall be transmitted to the Board not later than the last day of February. Copies of the prescribed form may be obtained on application to the Assistant Commissioners, not earlier than 1st February.

SECTION XV.

Advances to Managers.

Purpose of Advances. 83. The Board may, at their discretion, advance money to managers of schools upon approved security, to enable them to provide proper equipment and appliances for the teaching of practical science, and for similar purposes to be approved by the Board, and may agree to accept repayment of the money so advanced and interest by instalments.

Stipulation as to School Grant. 84. The Board, when they consider it just and expedient so to do, may stipulate with the manager of a school presenting students for examination in the natural and experimental sciences, that a certain portion of the school grant which shall thereafter become payable in respect of education in such school shall be applied to the provision of proper equipment and appliances for the practical teaching of these sciences in such school.

Repayment of Advance. 85. When such a stipulation has been made with the manager applying for an advance, the Board may agree with such manager that the amount of any instalment which shall accrue due on foot of the advance shall be deducted from the portion of the school grant for any future year which, by virtue of such stipulation, shall be applicable to the provision of the equipment and appliances in the last preceding rule mentioned, and in such case the Board may, notwithstanding any change in the managership of the school, deduct the amount of such instalment from such portion of the school grant for the future years.

Security. 86. An agreement under the last preceding rule for the repayment of an advance by instalments out of the portion of the school grant stipulated to be applied as mentioned in Rule 84, either by itself or together with such personal or other collateral security as the Board may, under all the circumstances of the case, think fit to require, may be approved by the Board, and when so approved shall be deemed to be approved security within the meaning of Rule 83, and of the Recommendations contained in the General Summary of the Report of the Commission mentioned in the Intermediate Education (Ireland) Act (1900).

SECTION XVI.

Finance.

87. All sums of money payable under the Intermediate Education (Ireland) Acts, 1878 to 1900, or under these or any future rules, and the expenses of carrying the Acts into execution—shall be paid out of the moneys of the Board generally.

SECTION XVII.

General Powers.

Power to enlarge time

88. Subject to the restrictions contained in the next following section the Board may by order, either general or special, enlarge the time appointed by these rules for doing any act or class of acts, and such order shall be valid, although made after the time appointed for doing such act shall have expired.

Publication of Results.

89. The Board may publish such particulars of the results of their examinations and such other information relating thereto as they may think fit.

Decisions of Board final upon title to exhibitions, &c.

90. The decisions of the Board upon the title to exhibitions, prizes, medals, and school grants, upon the amounts of exhibitions, prizes, school grants, and bonuses, upon the mode of applying exhibitions, upon the equipment and appliances necessary for the teaching of practical science and for similar purposes, upon the amounts necessary to be advanced therefor, upon or in relation to the character of and approval of the security therefor, and upon any question which may arise upon the construction of their rules, shall be final and conclusive.

SECTION XVIII.

Special Powers of the Board in cases of unforeseen difficulties, accidents or breaches of rules.

Power of Board to order a second examination.

91. In case of the occurrence of accidents or irregularities, or under other special circumstances, the Board may order a second examination to be held at such centre or centres as they shall think fit, in any portion of the matter of examination; and the marks

obtained at such second examination will, for all intents and purposes, be regarded as if they had been obtained at the first examination, unless the Board, when ordering the second examination to be held, shall otherwise direct.

Power to amend awards of examiners.

92. In case a student, through any mistake, shall not have been awarded the marks to which he was entitled on his answering, the Board may amend the award of the examiners in accordance with the facts, and adjudge such student to have passed, or to have passed with honours, or to have obtained an exhibition, a prize, or a medal, if he shall be entitled thereto by his marks as amended.

Power to disallow school grant in case of irregularities.

93. If the Board shall be of opinion that irregularities or malpractices have occurred at any centre, and from the nature or extent thereof shall come to the conclusion that the authorities or teachers of any school are to blame in the matter, they shall have power to direct that such school shall not be entitled to receive any school grant for such period as the Board may determine.

Late claims for school grant.

94. In case a manager fails to transmit to the Board on or before the 15th of October, his claim for a school grant, the Board may, in their discretion, allow the omitted claim to be received after that day; but the school grant payable in respect of such omitted claim will, unless the Board be satisfied of the sufficiency of the cause stated in explanation of the omission, be reduced by such sum not exceeding 10 per cent. as the Board may direct.

Late lists under Rule 65c.

95. In case a manager fails to transmit to the Board on or before the 1st November, the list of students upon the roll of the school on the 15th of October, the Board, if satisfied of the sufficiency of the cause stated in explanation of the omission, may, in their discretion, allow the omitted list to be received after that day, but the school grant which may become payable to such manager will be reduced by such sum not exceeding 25 per cent as the Board may direct

Omission of name from lists under Rule 65c.

96. In case a manager has omitted from the list of students upon the roll of the school on the 15th of October, the name of any student who might have been included therein, the Board, if satisfied of the sufficiency of the cause stated in explanation of the omission, may, in their discretion, allow the list to be amended by adding thereto the omitted name or names. A sum of £1 for each name so omitted shall be deducted from the school grant which may become payable to such manager.

Late May Declaration.

97. In case a manager fails to transmit to the Board, on or before the 21st May, the declaration prescribed in Rule 23, the Board may, in their discretion, allow the omitted declaration to be received after that day; but the school grant payable in respect of such omitted

declaration will, unless the Board be satisfied of the sufficiency of the cause stated in explanation of the omission, be reduced by such sum not exceeding 10 per cent. as the Board may direct.

Late schemes under Rule 62.

98. In case a manager fails to transmit to the Board, on or before the 1st October, the scheme for distribution of the Preparatory Grade Prize Fund under Rule 62, the Board, if satisfied of the sufficiency of the cause stated in explanation of the omission, may, in their discretion, allow the omitted list to be received after that day, but the school grant which may become payable to such manager will be reduced by such sum not exceeding 10 per cent. as the Board may direct.

Omission of name from Schemes under Rule 62.

99. In case a manager shall omit from the scheme for distribution of the Preparatory Grade Prize Fund under Rule 62, the name of any student who might have been included therein, the Board, if satisfied of the cause stated in explanation of the omission, may, in their discretion, allow the list to be amended by adding thereto the omitted name or names. A sum of 2*s.* 6*d.* for each name so omitted shall be deducted from the school grant which may become payable to the manager.

Late Lists under Rules 76 and 81.

100. In case a manager who proposes to present a choir or orchestra for examination, or for the special competition in Dublin, shall fail to transmit to the Board on or before the last day of February, the list of students composing such choir or orchestra, the Board, if satisfied of the sufficiency of the cause stated in explanation of the omission, may, in their discretion, allow the omitted list to be received after that day, but the bonus which may become payable to such manager will be reduced by such sum not exceeding 25 per cent. as the Board may direct.

101. Non-compliance by the Board with these rules shall not render void any of their acts.

SECTION XIX.

Definitions.

102. The following expressions in the rules are thus defined:—

"Department" means the Department of Agriculture and other Industries and Technical Instruction in Ireland and for other purposes connected therewith:

"educational year" means the period between the 15th day of October in any year and the 1st day of June in the succeeding year;

"experimental science" means the various courses specified in Rule 9 (a);

"honour subject" means any subject within Rule 7;

"honour marks" mean marks within the description in Rule 42;

"honour student" means any student who passes the examination with honours (Rule 39);

"manager" means 'manager of a school;'

"prescribed form" means such form as may, from time to time, be prescribed by the Board;

"school" means any educational institution (not being a National school) whose teaching comprises any of the courses as defined in the Board's programme in any grade higher than the Preparatory, and whose list of students under Rule 65 (c) in the year of the examination, contains the names of at least seven students within the prescribed limits of age.

"standard mark" means the average of the marks, counting towards an exhibition, obtained by the first five students in each Course of each Grade, respectively,

"student" includes girl as well as boy; and pronouns in the masculine gender include the corresponding pronouns in the feminine gender;

"subject" means any subject of examination in the programme;

"transmit" means to send by post or otherwise so as to reach the office within office hours on the day named in the Rule, or on the following day if the day named be a Sunday.

SECTION XX.

Commencement of rules.

103. These rules will come into operation on the 1st day of September, 1906, but will not apply to anything in relation to the examinations which shall have been previously held except Rules 47, 48, 49, 50 and 51, which shall apply to the results of the examinations held in 1906. All prior rules inconsistent with any of these rules shall be revoked from the times when these rules respectively shall come into operation

SCHEDULE

CONTAINING THE

PROGRAMME OF

EXAMINATIONS

IN THE

Preparatory, Junior, Middle, and Senior Grades

for 1907.

Preliminary Notes.

1. The Board do not, as a rule, recommend any particular text books. By "School Text" is meant some edition of the works referred to, which has been prepared for school use, and from which objectionable passages are omitted. The Board do not approve of the use of vocabularies where dictionaries are available.

2. In marking answer books regard will be had to spelling, handwriting, and the general neatness of the answers, and marks will be deducted from the total marks awarded to each answer-book for deficiencies in these points.

3. The questions on the pass examination papers are intended to be of such a character as may be answered by any student fairly well taught.

4. In the literary examinations in all Grades, but particularly in the Middle and Senior Grades, special credit will be given for the style of the translations from the classical or modern languages into English.

5. In the Preparatory and Junior Grades, knowledge of the prescribed authors in the various languages may be tested in parsing, analysis, paraphrasing, prosody, literature, history, and geography, by questions naturally arising out of the passages set for translation.

6. In the Preparatory and Junior Grades the passages for translation at sight will be chosen of a style and character similar to those of the authors prescribed; in the Middle and Senior Grades they will be chosen either from the authors prescribed as standards, or from others similar to them in style and character.

7. In the case of sufficient merit in Greek or Latin verse composition, additional marks may be awarded not exceeding 20 per cent. of the total honour marks in Greek or Latin obtained by the student. Full marks, however, may be obtained in Latin and Greek without verse composition.

8. The books prescribed to be read in connection with English composition are intended only to suggest the subjects in which the composition will be set; in the case of books prescribed under the head of literature, a special knowledge of the text will be expected.

The examiners have instructions to withhold marks in the cases of compositions which are irrelevant.

9. The honour course in the mathematical subjects will in every case include the pass course in the same Grade and subject.

PROGRAMME.

Preparatory Grade.

GREEK.

	Percentage of Marks
1. **XENOPHON**: Anabasis, Book I., omitting the speeches and chap. 9, with questions on grammar, &c., arising out of the text. (School text,)	40
2. Easy sentences for translation into Greek, the Greek for the more difficult words being supplied.	25
3. A passage or passages from some other Greek work or works for translation at sight, the meaning of the more difficult words being given.	20
4. Outlines (*i. e.* easy questions relating to the most remarkable events and personages, with dates) of Greek history down to B.C. 479.	15

LATIN.

1. (*a*) **CAESAR**: de Bello Gallico, Book I., chaps. 1 to 26 inclusive. (*b*) **OVID**: Fasti, Book II., lines 195 to 242, and Book IV., lines 809 to 852; Tristia, Book I., Eleg. 2, lines 19 to 56; and Eleg. 3, lines 1 to 26, and 79 to 102, with questions on grammar, scansion, &c., arising out of the texts.	40
2. Easy sentences for translation into Latin, the Latin for the more difficult words being supplied.	25
3. A passage or passages from some other Latin work or works for translation at sight.	20
4. Outlines (*i.e.*, easy questions relating to the most remarkable events and personages, with dates) of Roman History down to B.C. 241.	15

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE.	35

The following Ballads :—

(*a*) **SCOTT**; Alice Brand.
(*b*) **MACAULAY**: Battle of the Lake Regillus.
(*c*) **BROWNING**: The Pied Piper of Hamelin.
(*d*) **LONGFELLOW**: Robert of Sicily.

B—COMPOSITION.	65

Work to be read :—

KINGSLEY: The Heroes. (School text.)

HISTORY AND GEOGRAPHY.

	Percentage of Marks
1. History; outlines (*i.e.*, easy questions relating to the most remarkable events and personages, with dates) of the history of England and Ireland from the invasion of Britain by Julius Caesar to A.D. 1400; and outlines of the history of Europe in relation to that of England during this period. (The extent of knowledge of European history required will not exceed that to be found in Freeman's Primer, "Europe.")	70
2. Geography; the use of maps; size and shape of the earth; general outlines of the great divisions of the globe; outlines of the geography of Ireland.	30

FRENCH.

1. **XAVIER MARMIER**: Le Protégé de Marie Antoinette, Première Partie (school text); with questions on grammar, &c., arising out of the text.	30
2. A passage or passages from some other French work or works for translation at sight.	30
3. Easy sentences, colloquial phrases, and a short passage for translation from English into French, the French for the more difficult words being supplied.	40

GERMAN.

1. **GRIMM**: Märchen—Hänsel and Gretel; Aschenputtel; Frau Holle; Rotkäppchen; Dornröschen; with questions on grammar, &c., arising out of the text.	30
2. A passage or passages from some other German work or works, as well as a passage in German handwriting, for translation at sight.	30
3. Easy sentences, colloquial phrases, and a short passage for translation from English into German, the German for the more difficult words being supplied.	40

Students will not be required to write their answers in German handwriting.

IRISH.

1. (*a*) An Tarḃ Breac. (*b*) Sgeaċ Ṁic an Ċró.	30
2. A passage or passages from some other Irish author for translation at sight.	30
3. Easy sentences, colloquial phrases and a short passage for translation from English into Irish, the Irish for the more difficult words being supplied.	40

Percentage of Marks

ITALIAN.

1. **EDMONDO DE AMICIS**: Cuore, *Ottobre, Novembre*; with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Italian work or works for translation at sight. 30

3. Easy sentences, colloquial phrases, and a short passage for translation from English into Italian, the Italian for the more difficult words being supplied. 40

SPANISH.

1. **EDDY**: Amigos y Auxiliares del Hombre, pages 1 to 76 (Ginn y Compañia); with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Spanish work or works for translation at sight. 30

3. Easy sentences, colloquial phrases, and a short passage for translation from English into Spanish, the Spanish for the more difficult words being supplied. 40

ARITHMETIC.

First four rules, simple and compound; reduction, including metric system; questions soluble by simple and compound proportion or by the unitary method; vulgar fractions; non-recurring decimals; calculation of rectangular areas and rectangular volumes.

GEOMETRY.

1. Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid, book I., propositions—i. to xli. inclusive, omitting ii, vii, xix, xxiv, xxv, xxix; book III., propositions i, iii, xi, xii, xvi, xx, xxi, xxii, and xxxi. Easy deductions. 70

2. Practical.—Constructions corresponding to the theoretical course, involving the use of graduated ruler, compass, and set square. 30

ALGEBRA.

Pass

Addition, subtraction, multiplication, and division of algebraic integers; simple equations in one unknown quantity; easy problems soluble by such equations.

Junior Grade.

GREEK.

Percentage of Marks

Pass

1. XENOPHON : Anabasis, Book I., omitting the speeches and chap. 9.
   LUCIAN : Vera Historia, Book I. from Ὁρμηθεὶς γάρ ποτε ἀπὸ Ἡρακλείων στηλῶν to end (school text)
   with questions on grammar, &c., arising out of the texts. 30

2. Short sentences for translation from English into Greek, the Greek for the more difficult words being supplied. 30

3. A passage or passages from some other Greek work or works for translation at sight, the meaning of the more difficult words to be given. 30

4. Greek history down to B.C. 479. 10

Honours

1. More difficult sentences for translation into Greek; more difficult passages and questions on the pass course.

2. EURIPIDES : Troades, omitting the lyric portions ; with questions on grammar, &c., arising out of the text.

A short passage of English verse for translation into Greek iambics.

LATIN.

Pass

1. (a) CAESAR : de Bello Gallico, Book I.
   (b) OVID : Fasti, Book I., lines 539 to 582 ; Book II., lines 83 to 113 and 721 to 760 ; Book IV., lines 419 to 464, and 809 to 836, with questions on grammar, scansion, &c., arising out of the texts. 30

2. Short sentences for translation from English into Latin, the Latin for the more difficult words being supplied. 30

3. A passage or passages from some other Latin work or works for translation at sight. 30

4. Roman history from B.C. 241 to B.C. 133. 10

Percentage of Marks

Honours

1. More difficult sentences for translation into Latin; more difficult passages and questions on the pass course.

2. VIRGIL: Aeneid, Book VII., with questions on grammar, scansion, &c., arising out of the text.

A short passage of English verse for translation into Latin elegiacs or hexameters.

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE. 35

TENNYSON; Morte D'Arthur, commencing "So all day long" and ending "On the mere the wailing died away."
DICKENS: A Christmas Carol. (School text.)

B—COMPOSITION.

Work to be read:— 65

MARIA EDGEWORTH: Tales, viz.:—Murad the Unlucky; Lazy Lawrence; The False Key; The Lottery; The Barrington; To-morrow; Simple Susan. (School text.)

HISTORY AND GEOGRAPHY.

Pass

1. Outlines (*i.e.* easy questions relating to the most remarkable events and personages, with dates) of the history of England and Ireland from A.D. 1400 to 1689. 70

2. Outlines of the Political Geography of the British Empire. 30

Honours

More difficult questions on the pass course in History, with special knowledge of the reign of Charles I.

Outlines of the History of Europe in relation to England during the reign of Charles I. (such as is given in Freeman's *Primer*).

More difficult questions on the Political Geography of the British Empire.

Percentage of Marks.

FRENCH.

Pass

1. **DAUDET**: Le Petit Chose en Province; première partie (school text); with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other French work or works for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into French 35

Honours

1. More difficult sentences for translation into French; more difficult passages and questions on the pass course.

2. **GRÉVILLE**: A la Campagne; (school text,) with questions on grammar, &c., arising out of the text.

GERMAN.

Pass

1. **GOEBEL**: Rübezahl; Der Herr des Riesengebirges; Wie der Name "Rübezahl" entstand; Der Schustergeselle; Die Studenten; Die Kräutersammlerin; Der Herzog von Ratibor; Der starke Drescher; Susi; Die beiden Leineweber; Der seltsame Gast; Der Glashändler; (school text), with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other German work or works, as well as a passage in German handwriting, for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into German. 35

Students will not be required to write their answers in German handwriting.

Honours

1. More difficult sentences for translation into German; more difficult passages and questions on the pass course.

2. **GOEBEL**: Rübezahl. The following in addition to the pass course: Der arme Heinz; Der Prager Musikant; Bauer Veit; Der Handwerksbursche; (school text), with questions on grammar, &c., arising out of the text.

IRISH.

Pass

	Percentage of Marks.
1. Taḋg Gaba : with questions on grammar, &c., arising out of the text.	30
2. A passage or passages from some other Irish work or works for translation at sight.	35
3. Short sentences, colloquial phrases, and a passage for translation from English into Irish.	35

Honours

1. More difficult sentences for translation into Irish; more difficult passages and questions on the pass course.

2. Poll an Ṗiobaire : with questions on grammar, &c., arising out of the text.

ITALIAN.

Pass

1. **EDMONDO DE AMICIS** : Cuore, *Ottobre*, *Novembre Dicembre* ; with questions on grammar, &c., arising out of the text.	30
2. A passage or passages from some other Italian work or works for translation at sight.	35
3. Short sentences, colloquial phrases, and a passage for translation from English into Italian.	35

Honours

1. More difficult sentences for translation into Italian; more difficult passages and questions on the pass course.

2. **METASTASIO** : Temistocle; with questions on grammar, &c., arising out of the text.

Percentage of Marks.

SPANISH.

Pass.

1. **MANTILLA**: Libro tercero de lectura; from page 1 to 52 inclusive, Hachette et Cie., with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Spanish work or works for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into Spanish. 35

Honours.

1. More difficult sentences for translation into Spanish; more difficult passages and questions on the pass course.

2. **SAMANIEGO**: Fabulas; Books IV. and V., with questions on grammar, &c., arising out of the text.

BOOK-KEEPING.

Single and double entry; definitions of the terms used; form and purposes of the various books employed; recording of business transactions; posting, balancing, and closing the ledger; balance sheets; bills.

ARITHMETIC.

Preparatory Grade Course.

Practice; recurring decimals; percentages; averages; simple interest; square root; circumferences and areas of circles.

GEOMETRY.

Pass

1. Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid book I. book II., omitting propositions viii, ix, x, xi.; book III. as in the Preparatory Grade, together with propositions vii, viii, xiv, xv, xvii, xxvi (by superposition), xxxii, xxxiii, xxxv, and xxxvi. Easy deductions. 80

2. Practical.—Constructions corresponding to the theoretical course, involving the use of graduated ruler, compass, and set square. 20

Honours

The above theoretical course with more difficult deductions. No practical part.)

ALGEBRA.

Pass

Preparatory Grade course. Evaluation of algebraic expressions and their graphical representation; algebraic fractions; simple equations involving two unknown quantities; problems soluble by such equations.

Honours

Quadratic equations in a single unknown quantity; problems soluble by such equations; indices; surds.

SHORTHAND.

Dictation of short and simple sentences. Any system of shorthand may be used.

Middle Grade.

GREEK.

Pass

	Percentage of Marks
1. XENOPHON: Agesilaus. EURIPIDES: Troades, omitting lyric portions, with questions on grammar, &c., arising out of the texts.	30
2. Short passages from other Greek works for translation at sight.	30
3. English passages for translation into Greek.	30
4. Outlines of Greek history, from B.C. 479 to B.C. 399.	10

Honours

1. English passages for translation into Greek.	45
2. Passages from Greek authors for translation into English, with questions on grammar, &c., arising out of the passages. Standards for style and character of the passages. XENOPHON: Hellenica. EURIPIDES, omitting lyric portions.	40
3. Greek history, from B.C. 479 to B.C. 399.	15
4. A passage of English verse for translation into Greek iambics.	

LATIN.

Pass

1. CICERO: Pro Archia and pro Lege Manilia. VIRGIL: Aeneid, Book IX.; with questions on grammar, &c., arising out of the texts.	30
2. Short passages from other Latin works for translation at sight.	30
3. English passages for translation into Latin.	30
4. Outlines of Roman history, from B.C. 133 to B.C. 44.	10

Honours

1. English passages for translation into Latin.	45
2. Passages from Latin authors for translation into English, with questions on grammar, prosody &c., arising out of the passages. Standards for style and character of the passages. CICERO: Orations. VIRGIL: Aeneid.	40
3. Roman history, from B.C. 133 to B.C. 44.	15
4. A passage of English verse for translation into Latin elegiacs or hexameters.	

Percentage of Marks

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE.

MACAULAY: Essay on Addison. (School text).

MILTON: L'Allegro line 37 to end.

GRAY: The Elegy written in a Country Churchyard.

GOLDSMITH: The Haunch of Venison.

BYRON: Childe Harold; Selections from Canto IV. :—The Gladiator, stanzas 139 to 141 inclusive; (*b*) The Address to the Ocean, stanzas 178 to 183 inclusive.

MOORE: Echo; I saw from the Beach; Oft in the Stilly Night;

LONGFELLOW; The Ladder of Saint Augustine. 35

B—COMPOSITION.

Work to be read :—

SCOTT: The Talisman. (School Text.) 65

HISTORY AND GEOGRAPHY.

Pass

1. The History of Great Britain and Ireland from 1689 to 1789. 70

2. Political Geography of Great Britain and Ireland in relation to the same period, together with outlines of the Political Geography of Europe at the present time. 30

Honours

More difficult questions on the pass course in History, together with special knowledge of the reign of Anne, and general history in relation to it.

Political Geography in general in relation to the reign of Anne, together with outlines of the Political Geography of Europe at the present time.

FRENCH.

Pass

1. { **XAVIER DE MAISTRE**: Un Voyage autour de ma chambre. / **MOINAUX**: Les deux Sourds. } 30
with questions on grammar, &c., arising out of the texts.

2. Short passages from other French works for translation at sight. 35

3. Colloquial phrases and a passage of English for translation into French. 35

Honours

1. Passages from French authors for translation into English with questions on grammar, &c., arising out of the passages. 50

Standards for style and character of the passages. } **XAVIER DE MAISTRE.** **COPPÉE.**

2. Colloquial phrases, and a passage of English for translation into French. 50

Percentage of Marks

GERMAN.

Pass

1. **RIEHL**: Kulturgeschichtliche Novellen; viz.:—
Der stumme Ratsherr. Der Dachs auf Lichtmess.
UHLAND: Balladen und Romanzen, viz.:—
Siegfrieds Schwert; Der gute Kamerad; Des Knaben Berglied; Schwäbische Kunde; Klein Roland; Roland Schildträger; König Karls Meerfahrt; Taillefer; Das Glück von Edenhall; Des Sängers Fluch; Der blinde König (school text). 30

2. Short passages from other German works for translation at sight. 35
Students will not be required to write their answers in German handwriting.

3. Colloquial phrases and passage of English for translation into German. 35

Honours

1. Passages from German authors for translation into English, with questions on grammar, &c., arising out of the passages. 50

Standards for style and character of the passages. { RIEHL. UHLAND: Balladen und Romanzen.

2. Colloquial phrases, and passage of English for translation into German. 50

Students will not be required to write their answers in German handwriting.

IRISH.

Pass

1. (*a*) Trí Sgéalta.
(*b*) **HYDE**: Selections from Raftery's Poems; viz.:—
1. Caoineaḋ ar Ṫomás O'Dálaiġ. 2. Béal-áṫa-na-haibne. 3. Anaċ Cuain. 4. Caismirt an Ṗótaire. 5. An Ḟiġeadóir. 6. Bainḟeis an tSleaḋṫáin ṁóir. 7. Seanċus na Sgeiṫe to quatrain 78; 30
with questions on grammar, prosody, &c., arising out of the texts.

2. Short passages from other Irish works for translation at sight. 35

3. Colloquial phrases and a passage of English for translation into Irish. 35

Honours

1. Colloquial phrases and a passage of English for translation into Irish. 50

2. Passages from Irish works for translation into English, with questions on grammar, prosody, &c., arising out of the passages. 50

Standard for style and character of the passages. { Sgríbne Gaeḋilge an Aṫar Peadar Ua Laoġaire.

ITALIAN.

Pass

1. FUCINI: All 'Aria Aperta (Ed. Bemporad, Florence); TASSO: Gerusalemme Liberata, Cantos IV. and V.; with questions on grammar, &c., arising out of the texts. 30

2. Short passages from other Italian works for translation at sight. 35

3. Colloquial phrases and passage of English for translation into Italian. 35

Honours

1. Passages from Italian authors for translation into English, with questions on grammar, &c., arising out of the passages. 50

Standards for style and character of the passages. MACHIAVELLI: Historie Florentine. TASSO.

2. Colloquial phrases, and passage of English for translation into Italian. 50

SPANISH.

Pass

1. QUINTANA: Vida de Fr. Bartolomé de las Casas. CERVANTES: Episodes from Don Quixote—"The Adventure of the Wooden Horse," and "Sancho Panza's Governorship" (school text); with questions on grammar, &c., arising out of the texts. 30

2. Short passages from other Spanish works for translation at sight. 35

3. Colloquial phrases and passage of English for translation into Spanish. 35

Honours

1. Passages from Spanish authors for translation into English, with questions on grammar, &c., arising out of the passages. 50

Standards for style and character of the passages. QUINTANA. CERVANTES.

2. Colloquial phrases, and passage of English for translation into Spanish. 50

BOOK-KEEPING.

Junior Grade course extended to include:—stocktaking; provision for bad and doubtful debts; correction of errors; adjustment entries; partnership transactions; dealings in stocks and shares; transactions in connection with exports and imports.

ARITHMETIC.

Junior Grade course. Compound interest; profit and loss; stocks and shares; present worth and discount; use of logarithms.

Students are liable to questions requiring for their solution a knowledge of the metric system of weights and measures.

GEOMETRY.

Pass

1. Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid, books I., II. III., and IV.; easy deductions. 80

2. Practical.—Constructions corresponding to the theoretical course, involving the use of graduated ruler, compass, and set square. 20

Honours

The above theoretical course together with Euclid, book VI., the definitions of book V., and harder deductions. (No practical part).

Students may be required to give algebraical proofs of those properties of proportional magnitudes on which the establishment of the propositions of Euclid, book VI. depends.

ALGEBRA.

Pass

Junior Grade Pass course; simple equations involving two or more unknown quantities; quadratic equations in a single unknown quantity; problems soluble by such equations; indices; surds.

Honours

Junior Grade Honour course; theory of the quadratic equation; imaginary quantities; arithmetical and geometrical progressions.

TRIGONOMETRY.

Pass

General definitions of the trigonometrical functions; elementary identities; determination of the numerical values of the trigonometrical functions of 30° and 45° and their multiples; solution of right-angled triangles; rule of sines, formula for the cosine of an angle of a triangle, and easy questions on the solution of triangles dependent thereon.

Honours

Harder questions on the pass course.

SHORTHAND.

Dictation. Any system of shorthand may be used.

NATURAL PHILOSOPHY.

The measurement of length, area, and volume. Calculation of the area of simple figures and the volume of regular bodies.

The comparison of forces by the use of spring balances and elastic strings. The composition and resolution of forces in one plane by the principles of the parallelogram and triangle of forces.

The principle of moments with applications to levers. The balance. Mass. Weight and density. Centre of gravity, and simple cases of equilibrium. The action of friction in maintaining equilibrium. Stable, unstable, and neutral equilibrium.

Motion in a straight line with uniform velocity and with uniform acceleration. The momentum and energy of a moving body. The laws of motion and the measurements of force. Work. Potential energy. Elementary treatment of motion in a circle. The pendulum.

Pressure at a point in a fluid. Thrust on a plane area immersed in a fluid.

The principle of Archimedes. Specific gravity. Hydrometers. Simple hydraulic apparatus.

The pressure of gas. Boyle's Law. The barometer. The pump and other simple pneumatic apparatus.

Senior Grade.

GREEK.

Percentage of Marks.

Pass

1. A passage or passages of English prose to be translated into Greek. 45

2. Passages from Greek authors for translation into English, with questions on grammar, &c., arising out of the passages. 40

Standards for style and character of passages.
1. THUCYDIDES, the narrative portions; DEMOSTHENES, public orations.
2. HOMER.

3. Greek history, from B.C. 445 to B.C. 336 and outlines of Greek poetic literature and art within that period. 15

Honours

More difficult passages and questions on the pass course.

A passage of English verse for translation into Greek iambics.

LATIN.

Pass

1. A passage or passages of English prose to be translated into Latin. 45

2. Passages from Latin authors for translation into English, with questions on grammar, &c., arising out of the passages. 40

Standards for style and character of the passages.
1. LIVY.
2. HORACE. OVID: Metamorphoses.

3. Roman history, from B.C. 44 to A.D. 40, and outlines of Roman poetic literature and art within that period. 15

Honours

More difficult passages and questions on the pass course.

A passage of English verse for translation into Latin verse.

Percentage of Marks.

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE.

SHAKESPEARE: Richard II. (School text.) 35

LAMB: Essays of Elia:—*viz.*;

Oxford in the Vacation; The Two Races of Men; New Year's Eve; Mrs. Battle's Opinions on Whist; All Fools' Day; Imperfect Sympathies; Witches and other Night Fears; The Praise of Chimney-Sweepers; A Dissertation on Roast Pig.

B—COMPOSITION.

Work to be read:— 65

SCOTT: Waverley. (School text.)

HISTORY AND GEOGRAPHY.

Pass

1. The history of Europe during the Revolutionary period—1789 to 1815. 70

2. Political Geography in relation to the same period, in addition to the outlines of the Political Geography at the present time of Asia, Africa and America, excluding British possessions. 30

Honours

More difficult questions on the pass course.

FRENCH.

Pass

1. Passages from French authors for translation into English, with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages. { LAMARTINE.
ERCKMANN-CHATRIAN.

2. Colloquial phrases, and a passage of English prose for translation into French. 40

3. Outlines of the literary history of France in the 19th Century. 15

Honours

More difficult passages and questions on the pass course.

Percentage of Marks.

GERMAN.

Pass

1. Passages from German authors for translation into English with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages { FREYTAG. SCHILLER: Gedichte.

2. Colloquial phrases, and a passage of English prose for translation into German. 40

3. Outlines of the literary history of Germany from 1770 to 1830. 15

Students will not be required to write their answers in German handwriting.

Honours

More difficult passages and questions on the pass course.

IRISH.

Pass.

1. Colloquial phrases and a passage of English for translation into Irish. 45

2. Passages from Irish works for translation into English, with questions on grammar, prosody, &c., arising out of the passages. 40

Standards for style and character of the passages. { Bodaċ an Ċóta Laċtna. Aṁráin Ṗiarais Ṁic Ġearailt.

3. Outlines of the literary history of Ireland from the Norman Invasion to 1550. 15

Honours

More difficult passages and questions on the pass course.

ITALIAN.

Pass

1. Passages from Italian authors for translation into English with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages { MANZONI. ALFIERI.

2. Colloquial phrases, and a passage of English prose for translation into Italian. 40

3. Outlines of the literary history of Italy in the 18th and 19th Centuries. 15

Honours

More difficult passages and questions on the pass course.

Percentage of Marks

SPANISH.

1. Passages from Spanish authors for translation into English, with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages { MENDOZA.
CALDERON.

2. Colloquial phrases, and a passage of English prose for translation into Spanish. 40

3. Outlines of the literary history of Spain from the middle of the 16th century to the death of Calderon. 15

Honours

More difficult passages and questions on the pass course.

BOOK-KEEPING.

The Middle Grade course, and in addition an elementary knowledge of the following subjects:—auditing; accounts of bankrupts, executors and trustees; bookkeeping and liquidation limited liability companies; the tabular method; and banking with special reference to the function and administration of the Bank of England.

ARITHMETIC.

Arithmetic in all its branches; mensuration of the cylinder, pyramid, cone, and sphere.

GEOMETRY.

Pass

(1) Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid, books I., II., III., IV., VI., with definitions of book V.—easy deductions. 90

(2) Practical.—Constructions corresponding to the theoretical course involving the use of graduated ruler, compass, and set square. 10

Honours

The above theoretical course, together with Euclid, book XI., propositions i. to xxi. inclusive—harder deductions. (No practical part.)

ALGEBRA.

Pass

Middle Grade Pass course in algebra.| Arithmetical and geometrical progressions.

Honours

Middle Grade Honour course; permutations; combinations; binomial theorem and applications; elimination; simultaneous quadratic equations, and equations reducible to such, and questions leading to them; exponential and logarithmic series.

TRIGONOMETRY.

Pass

Trigonometry up to and including the solution of plane triangles; simple cases of inverse functions; properties of circumscribed, inscribed, and escribed circles of a triangle.

Honours

Harder questions on the pass course.

SHORTHAND.

Dictation. Any system of shorthand may be used.

NATURAL PHILOSOPHY.

Same course as in Middle Grade.

Programme for Music.

The editions referred to in this Programme are for purposes of identification—no special edition is prescribed.

PREPARATORY GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises, Book I., Nos. 4, 6, 7, 8, 12, 15, 17; 18, Preliminary 1st Form, for Clavier, *or* Schmitt: Preparatory Exercises, Nos. 10 to 33, for Piano.
	2. Scales	Major scales of C, G, F, D, A. Harmonic minor scales of A, E, D, B. Hands separate and together. Compass, 2 octaves.
	3. Arpeggios	Major common chords of C, G, F, D, A. Minor common chords of A, E, D, B in close position. Hands separate. Compass, 2 octaves.
	4. Pieces	(*a*) An easy sonatina by Steibelt, Enckhausen, Schmitt, or Reinecke; and (*b*) Two "Album Leaves" from Op. 101, Gurlitt.

or

VIOLIN.	1. Scales	Major and melodic minor scales of G, A, B flat. Compass, 2 octaves, detached.
	2. Arpeggios	Arpeggios of above scales. Compass, 2 octaves, detached.
	3. Studies	Two studies: any two studies from Hermann, *Violin School*, Part I. (Peters).
	4. Pieces	Two pieces: any two pieces from Dancla, *Petite Ecole de la Mélodie*, Book I., Op. 123 (Schott).

or

VIOLONCELLO.	1. Scales	The major scales of C, G, D, A, F, B flat. Compass, one octave, in first position. A whole bow for each note.
	2. Arpeggios	The major common chords of the above scales. Compass, one octave, in first position. A whole bow for each note.
	3. Studies	Two studies: Schrœder, *Die Ersten Violoncello-Uebungen*. Op. 31, No. 9, (Peters), and another of equal difficulty.
	4. Pieces	Two pieces: Goltermann, *Contentment*, Op. 118, No. 5 (Augener), and another of equal difficulty.

or

HARP.	1. Scales	Major scales of C, G, D, A, E, F, with hands separate and hands together, one octave apart. Compass, 2 octaves.
	2. Arpeggios	Arpeggios of above scales, with separate hands. Compass, 2 octaves.
	3. Studies	Two studies: Bochsa's *Pupil's Companion*, Book 2, No. 18 (Ashdown), and another of equal difficulty.
	4. Pieces	Two pieces: Bochsa's *Sequel. Prelude and Lessons*, No. 8 (Chappell), and another of equal difficulty.
	5. Reading at Sight	To play at sight a very easy exercise.
	6. Ear Test	From C (middle) as tonic, and G (2nd line treble) as tonic, to recognise and name the notes of major common chord above these notes.
	7. Harmony	A knowledge of triads, triads in a key. Normal 8-bar sentence. Cadences. Chord progressions. Selection of roots for the harmonization of a given 8-bar melody. (See *First Principles of Harmony*, by S. S. Myerscough, Part I., Sec. II. This work is not prescribed, but is mentioned as indicating the extent of knowledge required.)

JUNIOR GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises. Book I, Nos. 13, 15, 19, 25, 18 Preliminary, and Form, for Clavier, *or* Schmitt: Preparatory Exercises, Nos. 31 to 64, for Piano.
	2. Scales	All the major scales. All the minor scales in harmonic form. Hands separate and together. Compass, 2 octaves.
	3. Arpeggios	All the major and minor common chords, in close position. Hands separate and together. Compass, 2 octaves.
	4. Studies	Two studies: Pauer, No. 1 in C of 24 *Studies* (Augener 8326), and another of equal difficulty.
	5. Pieces	Two pieces of Beethoven, Menuetto from Sonata in D, Op. 10, No. 3 (Peters), and another of equal difficulty.

or

VIOLIN.	1. Scales ...	Major and melodic minor scales of G, A, B flat, B natural, C, D. Compass, 2 octaves, (*a*) detached, (*b*) slurred in eights.
	2. Arpeggios ...	Arpeggios of above scales. Compass, 2 octaves, detached.
	3. Studies ...	Two studies: any two studies from Hermann *Études Spéciales*, Part I. (Augener).
	4. Pieces ...	Two pieces: Bohm, *Sechs Vorspielstücke*, No. 5, Intermezzo (Lengnick), and another of equal difficulty.

or

VIOLONCELLO.	1. Scales ...	Major scales of D, A, F. Minor scales (harmonic form) of A, D, G. Compass, 2 octaves, (*a*) detached, (*b*) slurred in fours.
	2. Arpeggios ...	The major and minor common chords of the above scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in threes.
	3. Studies ...	Two studies: Schrœder, *Die Ersten Violoncello Uebungen*. Op. 31, No. 18 (Peters), and another of equal difficulty.
	4. Pieces ...	Two pieces: Burgmüller, No. 1 of *Three Nocturnes* (Augener), and another of equal difficulty.

or

HARP.	1. Scales ...	All the major scales, with hands separate and hands together, one octave apart. Compass, 2 octaves.
	2. Arpeggios ...	Arpeggios of major scales, with hands separate and hands together, one octave apart. Compass, 2 octaves.
	3. Studies ...	Two studies: Bochsa's *Pupil's Companion*. Book 2, No. 20 (Ashdown), and another of equal difficulty.
	4. Pieces ...	Two pieces: Alvar's *Romances*, Book 4, No. 20 (Hutchings and Romer), and another of equal difficulty.

6. Reading at Sight ...	As in the Preparatory Grade, the exercise, however, being of a more advanced character.
7. Ear Test ...	From C (middle) or G (2nd line treble) as tonics, to recognise and name any note within the major octave scale, above.
8. Harmony ...	Preparatory Grade Course. In addition, the laws of part-writing. Inversion of triads. Figuring for triads and their inversions. (See *First Principles of Harmony*, Part I., Secs. II. and III.)

MIDDLE GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises. Book I. Nos. 26, 29, 30, 37, 18 Preliminary, 5th Form, for Clavier, *or* Schmitt: Preparatory Exercises. Nos. 120 to 160, for Piano.
	2. Scales	All the major scales. All the minor scales in harmonic form. Chromatic scales beginning on any key-note. Hands separate and together. Compass, 3 octaves.
	3. Arpeggio	All the major and minor common chords in extended position. Hands separate and together. Compass, 3 octaves.
	4. Studies	Two studies: Heller, *Study in C*, op. 47, No. 1 (Augener, 6187), and another of equal difficulty.
	5. Pieces	Two pieces: Haydn, *Presto* (*Finale*) *from Sonata in G* (Peters, 713*a*, No. 10), and another of equal difficulty.

or

VIOLIN.	1. Scales	All major, harmonic, and melodic minor scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in eights.
	2. Arpeggio	Arpeggios of major and minor common chords. Compass, 2 octaves, (*a*) detached, (*b*) slurred in threes.
	3. Studies	Two studies: any two studies from Kreutzer, 40 Studies (Peters).
	4. Pieces	Two pieces: any two pieces from David, *Bunte Reihe* (Augener).

or

VIOLONCELLO.	1. Scales	Major scales of D, A, F, B flat. Minor scales (harmonic form) of A, G, C, E. Compass, 2 octaves, (*a*) detached, (*b*) slurred in fours.
	2. Arpeggios	The major and minor common chords of above scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in threes.
	3. Studies	Two studies: Dotzauer, *Forty Studies*, No. 3 (Augener), and another of equal difficulty.
	4. Pieces	Two pieces: Mendelssohn, *Romance sans Paroles* (Novello), and another of equal difficulty.

HARP.	1. Scales	Major and harmonic minor scales, with hands separate and hands together, one octave apart. Compass, 3 octaves.
	2. Arpeggios	Arpeggios of major and minor scales, with hands separate and hands together, one octave apart. Compass, 3 octaves.
	3. Studies	Two studies: Bochsa's *Pupil's Companion*, Book 3, No. 28 (Ashdown), and another of equal difficulty.
	4. Pieces	Two pieces: John Thomas, *The Tear* (Hutchings and Romer), and another of equal difficulty.
	6. Reading at Sight	An easy piece or song accompaniment (omit song accompaniment for violin and 'cello.)
	7. Ear Test	To recognise and name any note of chromatic scale, with middle C as tonic, within compass of octave above or below.
	8. Harmony	Junior Grade course. In addition, the chord of the dominant 7th and its inversions, Cadential $^6_4$, passing $^6_4$. A given figured hass or 8-bar melody to test knowledge of the foregoing. (See *First Principles of Harmony*, Part I., Secs. II. to VII., inclusive.)

SENIOR GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises, Nos. 174, 176, 177, for Clavier, *or* A third study, of the same difficulty as the piece prescribed as a study in 4 *infra* for Piano.
	2. Scales	All the major scales. All the minor scales in harmonic and melodic forms. Chromatic scales beginning on any key note. Hands separate and together. Compass, 4 octaves.
	3. Arpeggios	All the major and minor common chords and their inversions, in extended position. Hands separate and together. Compass, 4 octaves.
	4. Studies	Two studies: Bach, *Fugue in two parts in C minor* (Peters, 200, No. 3). and another of equal difficulty.
	5. Pieces	Two pieces, Beethoven, *Presto alla tedesca, from Sonata in G*, Op. 79, No. 25 (Peters), and another of equal difficulty.

or

VIOLIN.	1. Scales	All major, harmonic, and melodic minor scales. Scales of G, A flat, A natural, B flat, B natural in 3 octaves; all others, 2 octaves, (*a*) detached, (*b*) slurred in eights. Chromatic scales, beginning on any note. Compass, 2 octaves, slurred in eights.
	2. Arpeggios	Arpeggios of major and minor common chords, (*a*) detached, (*b*) slurred in sixes. Compass, 2 octaves.
	3. Studies	Two studies: Mazas, *Studies*, Book 1., Op 36 (Litolff), and another of equal difficulty.
	4. Pieces	Two pieces: Mozart, Adagio in E, (Augener, 7420), and another of equal difficulty.

or

VIOLONCELLO.	1. Scales	All the major scales. All the minor scales (harmonic form). Compass, 2 octaves, (*a*) detached, (*b*) slurred in eights.
	2. Arpeggios	The major and minor common chords of above scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in sixes.
	3. Studies	Two studies: Dotzauer, *Études*, Op. 107, No. 8 (Peters), and another of equal difficulty.
	4. Pieces	Two pieces: Marcello, Sonata in G minor, First movement (Augener), and another of equal difficulty.

or

HARP.	1. Scales	Major scales. Harmonic and melodic minor scales, with hands separate and hands together one octave apart. Compass, 3 octaves.
	2. Arpeggios	Arpeggios of major and minor common chords. Chords of the dominant and diminished 7th, with hands separate and hands together, one octave apart. Compass, 3 octaves.
	3. Studies	Two studies: Bochsa's *Forty Studies*, Book I., No. 6 (Chappell), and another of equal difficulty.
	4. Pieces	Two pieces: Handel, *Harmonious Blacksmith* (Hutchings and Romer), and another of equal difficulty.

6. Reading at Sight	A piece about as difficult as Junior Grade "pieces."

7. Ear Test	To recognise and name any interval within compass of an octave, between G below middle C of piano and G above the treble stave.
8. (*a*) Harmony	(*a*) Middle Grade course. Secondary 7th chords. Suspensions. Appoggiaturas, and auxiliary notes. A given figured bass, or a given 8-bar melody, to test knowledge of foregoing. (See *First Principles of Harmony*, Part I., and Secs. II. and III. of Part II.)
(*b*) Form	(*b*) Elements of Form, for Sonata.
(*c*) History of Music	(*c*) Sketch of the lives of eminent musicians, with knowledge of their influence on music.

The part of the Programme of the Department of Agriculture and Technical Instruction for Ireland entitled "*Programme of Experimental Science, Drawing, Manual Instruction, and Domestic Economy for Day Secondary Schools, Regulations and Syllabuses, Session* 1905-6," distinguished as XI., commencing on page 37 and ending on page 167 thereof, with the exception of the Syllabuses for the Auxiliary Course of Domestic Economy, commencing on page 147 and ending on page 149 thereof.

SYLLABUSES OF EXPERIMENTAL SCIENCE, DRAWING, AND DOMESTIC ECONOMY.

(1.)—PREFATORY NOTE.

Instruction in Experimental Science has now taken an important place as an element in a general education. In order to maintain its position it is not necessary that it should displace other branches of education no less important, which, indeed, it should supplement and subserve. To secure the full advantages which the study of Experimental Science has to confer, it is necessary to constantly keep in mind the purposes which such a course should serve. The principal functions of a well-designed course are—

(1.) The education of the power of observation, involving the exercise of judgment and the training of the senses.
(2.) The training of the reasoning powers.
(3.) The training of the executive powers. The experimental work performed by the pupils themselves involves the cultivation of manual dexterity, initiative, and self-reliance.
(4.) The imparting of some of the more important principles and facts of physical science.

For the realisation of these aims the course of instruction must be carefully planned and carefully taught. It will be seen that the method of teaching is regarded as being of greater importance than the mere imparting of knowledge, and that the best results of the training are not such as can be ascertained by a written test. A knowledge of the facts of science, however important, is secondary to the training in "scientific method" which the course is designed to confer. Not that the scientific method is a method peculiar to science; it is the same as that employed in business. In the investigation of scientific phenomena, however, the facts are more readily ascertainable, and the argument is free from those perturbing elements that enter into problems concerning human relationships.

What, then, is the scientific method? Enquiry into the history of the establishment of any great principle of physical science shows with more or less distinctness three distinct steps or processes :—

(1.) The collection and recording of observed facts.
(2.) The attempt to connect or explain the observed facts by framing a theory or hypothesis to account for them.
(3.) The attempt to establish the hypothesis by deducing a consequence arising from it and testing this by experiment.

The first two steps belong to induction. The third, which is deductive, was commonly employed in the middle ages until Bacon pointed out the importance of observation. The first step may obviously be taken by different individuals at various times. The second, implying a wide knowledge of the observed phenomena, involves the exercise of the highest reasoning power; experience has shown the danger of too little as well as too much theory. In the former case observations tend to become purposeless—in the latter, to introduce a preferential factor tending to vitiate the accuracy of the observations. The third step—verification—consists of two stages, (*a*) the deducing of a consequence of the hypothesis and (*b*) the testing of this by experiment.

When a hypothesis has thus been fully established it is termed a principle or a "law of Nature"—a somewhat unfortunate term since a "law of Nature" is nothing but a generalisation—a statement of an observed uniformity in the relations of phenomena—and is liable to revision as soon as wider knowledge may reveal an exception to the generalisation.

The history of science abounds in illustrations of the application of "scientific method." The discovery of the laws of planetary motion, the laws of gravitation, the planet Neptune, and the constitution of our atmosphere, are instances.

A course of instruction in science which neglects the enormous educative importance of a training in the scientific method loses the larger portion of its educational value. The mere acquisition of the facts of science—assuming it possible to convey them without practical work—must be regarded as quite secondary in value to the mental training and discipline involved by following out a few simple lines of investigation involving the exercise of the observing and reasoning faculties. This method, which has been called the "research" or "heuristic" method, involves the exercise of the highest powers of a teacher. It is less a method than a guiding principle. It requires that he should do less for his pupil than was common where a knowledge of facts was the sole aim, but the little required must be intensely purposeful. In fact, the teacher should avoid telling his pupils anything which they may fairly be expected to find out for themselves, and one of his highest functions is that of bringing clearly home to them the nature of the problem to be solved and the method by which it may be investigated. In certain cases it may be found desirable to establish a fact by the method of verification.

The full curriculum of instruction laid down in the following syllabuses consist of a two years' Preliminary Course followed by a two years' Special Course. The Preliminary Courses deal with fundamental principles, and, in addition to providing exercises in observational work, principally weighing and measuring, afford ample opportunity for the study of experimental methods. While the same method should inspire the work of the third and fourth year courses, and while the course should be strictly experimental, more attention may be paid to theory, and the student may now be referred to the observations of others. Text-books may now with advantage be used, and the student will be in a position to appreciate the results obtained by experienced workers in the field of science. The Special Course should, as far as possible, be selected with a view to the future possible career of the student.

Preliminary Course.

A study of the first and second year syllabuses will show that the work is mainly observational in character, and deals largely with weighing and measuring. Great attention should therefore be attached to accuracy. If a sufficiently high standard be held before them and suitable instruction in manipulation be given, young students are able to attain a considerable degree of accuracy in weighing and measuring. They should be expected to obtain results fairly within the limits rendered possible by their apparatus, the due care of which forms an important part of their training. That portion of the syllabus which deals with Mensuration is regarded as important, but the amount of time to be devoted to it will to some extent depend upon the pupils' previous knowledge.

It will be found of considerable advantage to keep the class together as far as possible, so that the teaching may be "collective." At the end of each practical lesson the results obtained should be collated and discussed, and a general conclusion drawn. It would be difficult to over-estimate the value of this portion of the lesson, which should include oral questions requiring clearly-expressed replies. When the results are tabulated and widely erroneous ones rejected, and the cause of the errors explained, the value of a "mean" result can be brought home. A word may here be said about arithmetical results. These frequently pretend to an impossible degree of accuracy. It is misleading and uselessly wearisome to carry a calculation further than the accuracy of the factors warrants. The importance of standards of length and mass should be made clear and the legal standards carefully described. The exercises in Mensuration should not be confined to small objects. The areas of the floor of the class-room, the top of the bench, the playground (measured with a tape or chain) should be varied with the smaller objects in use in the laboratory. The volume of a water tank or cylinder, the weight of a mass of masonry (calculated from volume and density), and such like exercises, will impress upon the young pupil the practical aim of his laboratory work. The measurements should be made both in English and Metric units.

Great importance is attached to the pupils' records of laboratory work. They form a permanent record of the pupil's own work, and should as far as possible be expressed in his own words, though the form in which they are to be made will necessarily be a matter for careful direction. Without running the risk of stereotyping what should to some extent give scope for initiative, the following suggestions respecting these records may be made:—

(*a*.) The note-books should be large, of uniform size, and should contain pages of squared paper for "graphs."

(*b*.) A statement of the object of the exercise should precede a terse description of the method of performing it, and this should be illustrated by simple *diagrammatic* sketches of the *essential* parts of the apparatus employed. These sketches take the place of wordy descriptions.

(*c*.) The results obtained should be entered up at once, in ink. The recording of observed measurements on scraps of paper until it is ascertained by calculation how far they accord with an anticipated result, is to be deprecated. The observation is likely to be more carefully made if it be regarded as unalterable.

(*d*.) The observations should be honestly recorded, no matter how far the result may differ from the result expected. Any attempt to "adjust" observed measurements to an expected result should be treated as a serious defect.

The source of a serious error subsequently ascertained may be recorded in a footnote—it will have a definite educational value.

(*e*.) The records should state shortly the inferences drawn from the observations.

(*f*.) The records should be revised. An inconclusive exercise, or one in which the result is very wide of the truth, should never be allowed to pass without an explanation of the cause of failure.

(*g*.) All exercises should be dated.

Attention may be drawn to the curving of results, to express the relation between two varying quantities. Facts not readily gathered from a table of figures become obvious from a curve, The following are a few only of the results in the first year course which may be so treated:—

English and Metric units of length;
Circumference and diameter of circles;
Diameter and volume of spheres.
Length and period of swing of pendulum;
Extension and pulling force of a spring;
Pressure and volume of a mass of gas;
Density and temperature of water near freezing point;
Fahrenheit and Centigrade thermometric scales.

In order to obtain the greatest value from the course, every pupil should work practically through the exercises involved. This precludes working the pupils in groups, and only where it is impossible to arrange otherwise should they be allowed to work in pairs. It is invariably found that one of the pair does the work and the other loses the full value of the training. There are probably a few exercises in the course where a careful demonstration by the teacher might usefully replace work by the student, as *e.g.*, the composition of water by synthesis. The cases are few, however, and the notes of them should indicate that the results obtained were not the work of the pupil.

In a scheme where mental training is regarded as the main thing to be aimed at and the mere knowledge of facts as subordinate, the logical treatment of the course should always command the consideration of the teacher, and the exercises should be devised with this end in view. For example, suppose the subject in hand is that of specific gravity. The pupil has already found that substances differ in density, and has found the weight of one cubic centimetre of various solids and liquids. Nothing, however, has been done to suggest to him the principle of Archimedes.

How may he be led to find it out? A course such as the following suggests itself:—

Take a mass of some substance, say iron, and immerse in a vessel quite full of water. The displaced water, which is equal in volume to the mass of iron, is carefully collected and weighed. The mass of iron is now weighed in air and in water. The loss of weight in water is at once seen to be equal to the weight of the water displaced, *i.e.*, to that of a volume of water equal to the iron. If the experiment be repeated with different solids and liquids the principle of Archimedes is arrived at without difficulty.

Other parts of the syllabus, as *e.g.*, the study of the composition of air, the rusting of metals, etc., offer excellent opportunities for the study of scientific method.

The Preliminary Course includes drawing of a simple character. At this stage drawing cannot be regarded as much more than an extension of writing—its object being a means of expression. Every effort should be made to co-ordinate it with the teaching of science, and examples for memory and object drawing should, where possible, be chosen from the laboratory.

Special Courses.

The full course now provides syllabuses for special courses of instruction in—

- Physics,
- Chemistry,
- Mechanical Science,
- Botany,
- Physiology and Hygiene,
- Geology,
- Domestic Economy,
- Drawing.

It is hoped that schools will exercise a wise discretion in the choice allowed in regard to the special courses, and that they will be selected with a view to local needs. In the case of girls' schools especially, attention is drawn to the courses in Domestic Economy and Physiology and Hygiene.

General remarks on method of treatment accompany the special course syllabuses. In these courses the thoughtful teacher will form his own methods, but they should be inspired by the principles which underlie the treatment of the preliminary courses. In these it will be found possible to apply the historical method with advantage, and teachers are advised to study carefully the history of the branch of science with which they are dealing.

At the conclusion of the full course the student should not only have an intelligent grasp of the elementary principles of science, but he should have gained something of the true spirit of scientific enquiry. This cannot fail to beget an appreciation of the limitations of his own knowledge, and an attitude of reverence in regard to the wide unexplored tract in the region of science.

(2.)—PRELIMINARY COURSE OF EXPERIMENTAL SCIENCE AND DRAWING.

(*a.*)—EXPERIMENTAL SCIENCE.

FIRST YEAR SYLLABUS.

1. *Measurement of Length.*—English and metric measures of length; comparison of one system with the other by actual measurements. Standards of length. Measurements of lengths of straight and curved lines. Use of parallel blocks: calipers. Determination of ratio of circumference of circle to diameter. Use of micrometer and vernier.

2. *Measurement of Area.*—Units of area. Reasons for expression of areas as squares. Direct methods of determining the areas of regular figures: by actual division into square cms., the fractions being estimated at sight; by means of squared paper; and by measurement of linear dimensions. Indirect methods of determining areas. Use of cardboard or other material in the determination of areas. Area of circle, deduced from the relation between the weight of a circle of cardboard and the weight of a square of the

same cardboard of side equal to the radius of the circle; and in other ways. Indirect methods of determining ratio of circumference of circle to diameter. Verification of some of the propositions of Euclid, as *e.g.*, I., 47.

3. *Measurement of Volume.*—Units of volume. Reasons for expression of volumes as cubes. Direct calculation of the volumes of regular solids from measurements of their linear dimensions. Use of fluid measures: burette, pipette, graduated cylinders, &c. Indirect measurement of volume.

4. *Measurement of Mass and Weight.*—Units and Standards. Distinction between mass and weight. Experiments on the extension of a spring or rubber cord by various weights. Equilibrium of a lever with two or more weights. Principle of moments. Use of lever to determine an unknown weight. Principle of the balance. Definition of centre of gravity. Determination of the centre of gravity of laminæ of various shapes.

5. *Measurement of Density.*—From measurements of volume and weight find the weight of one c.c. of various solids and liquids. Weight of one c.c. of water. Definition of density. Density of liquids determined by means of (1) burette and balance; and (2) bottle. Beginning with the observation that a brick appears to lose weight when immersed in water, carry out a series of experiments with solids of various sizes and with different liquids, in order to bring out that the apparent loss of weight depends on the volume of the solid and on the density of the liquid used, thus leading up to a statement of the principle of Archimedes. Use of this principle to determine volume and density of solids, and density of liquids. Extension of the principle to substances lighter than water, thus leading to the law of floating bodies. Use of hydrometers in determining densities.

6. *Fluid Pressure.*—The foregoing experiments having shown that liquids are capable of exerting an upward pressure or thrust on bodies immersed in them, further experiments may be carried out to bring out more fully the laws of fluid pressure; these should include experiments with U and inverted Y tubes possessing limbs of equal and unequal bore (incidentally the densities of liquids may be determined by measuring balancing columns) and the measurement of pressures of gases by the lengths of columns of liquids which they can support.

7. *Barometer.*—The pressure of the atmosphere and the weight of a known volume of it should receive consideration at this stage; and this would lead to the construction of the barometer. Reading of barometer; standard barometer. Effect of introducing air, water, etc., above the barometric column. Determination of the weight of one litre of air, under conditions existing in room by expelling air from a flask.

8. *Boyle's Law.*—Investigation of the relation between the pressure and the volume of a gas at constant temperature. Curves exhibiting the relations between P. and V., between P. and $\frac{1}{V}$, or $\frac{1}{P}$ and V.

9. *Measurement of Time.*—At this stage should follow some exercises on the pendulum in order that the pupils may understand the principle of the pendulum as a time measurer, and also that they may be exercised in time measurements, such as are required for heat experiments. Pendulum: relation between the number of

vibrations in a given time and the length of the pendulum. Period of vibration independent of mass of "bob," and—within moderate limits—of the arc of swing.

10. *Heat*—Effect of increase of temperature on volume of given mass of solid, liquid, gas—qualitatively. Determine, as far as possible, whether expansion and contraction are regular or irregular. Expansion a means of determining *hotness* or temperature. The thermometer and its fixed points. Comparison of Centigrade and Fahrenheit thermometers. Coefficients of expansion—gas, solid, liquid—using dilatometer tube only and *not* weight thermometer. Conductivity and comparison of conductivities by simple methods.

SECOND YEAR SYLLABUS.

The exact starting point of the Second Year's work will depend on the extent of that done in the First Year. But the second year must be mainly devoted to work of the character outlined below.

1. Laboratory work should begin with the observation of the apparent differences (form, colour, &c.) of some common and some laboratory substances, such as sand, soda, salt, alum, nitre, blue vitriol, green vitriol, salammoniac, sulphur, sugar, wood. The effect of heating these substances, and of hot and of cold water on them, should be tried; their behaviour towards litmus and turmeric should be ascertained. In this way much will be learned about distillation, evaporation, solution, crystallisation and filtration.

2. *Fuller Study of Solution.*—The observation having been made that many substances are more soluble in hot than in cold water, the solubility of such substances as salt and saltpetre should be found at the laboratory temperature, and say at 50°C. Solubility curves should be obtained later in the course when the pupils are more skilful in manipulation.

3. *Study of the rusting of Iron.*—It is a matter of common knowledge that a clean iron surface when exposed to moist air becomes dull: the examination of this change forms an interesting study. Comparison of bright iron with rusted iron to bring out qualitatively the physical differences. What are the conditions of rusting? will iron rust in dry air? in water free from air? in moist air? Recall the experiments on density and determine the density of iron and of iron rust. Weigh a quantity of iron filings; rust, weigh again. How may the difference in density, and the increase of weight be accounted for? Allow iron to rust in air enclosed over water; examine from day to day; test residual air to bring out alteration in volume and in properties. Existence of two constituents in air; an active and an inactive. Substances such as phosphorus, candle, spirit, and sulphur, which burn easily in air, should be burned in confined volumes of air, and the products of combustion, as well as the residual air, carefully examined—quantitatively, whenever possible.

4. *Action of Heat on Metals.*—Attention should be directed to the formation of smithy scale on iron when heated; and experiments should be carried out with iron and other metals to ascertain, first qualitatively, and then quantitatively, what changes occur when they are heated. The similarity between the formation of the metallic calces and iron rust will thus be brought out.

5. *Further study of the active constituent of Air.*—The various metalic calces or rusts should be heated to find out whether they will give up the active air which they contain. Mercury calx and

red lead will be found to give off a gas in which a glowing match bursts into flame, which will be wholly absorbed by moist iron filings, and which, when mixed with four times its volume of inactive air, forms a mixture possessing the same properties as air. It may thus be concluded that active air has been obtained. In order to save time and expense, prepare large quantities of the gas from chlorate of potash or permanganate of potash. Study the properties of the gas; the name "oxygen"; definition of an oxide; theory of combustion.

6. *Preparation of the common acids and alkalies.*—In heating green vitriol it will have been observed that acid fumes are evolved, and in this manner the production of oil of vitriol may be introduced. By the action of this substance on nitre and rock-salt the other two common acids should be prepared. Qualitative study of caustic soda, caustic potash, and ammonia may follow. Preparation of salts by careful neutralisation of these alkalies would now form very useful exercises.

7. *Study of Chalk.*—Chalk was early a subject of chemical research; and much may be learnt from a study of it. Note its obvious properties, and then the effect of heating it. Differences between chalk and lime in their behaviour towards water and litmus. Quantitative study of the change effected in chalk by strongly heating it—loss of 44 per cent. Collection of the gas and study of its properties; behaviour towards litmus and lime water. Action of acids on lime and chalk qualitatively and quantitatively. Collection of gas from acid and chalk; identity with that produced by heating chalk. Measurement of volume and weight of gas obtained in this way from one gramme of chalk; compare numbers with those obtained from heating one gramme of chalk. Burn magnesium in the gas; presence of carbon and oxygen suggested. Burn carbon in oxygen; shake up residue with lime water; identity established between gas obtained from chalk and that produced on burning carbon in oxygen. Hard and soft water. Synthesis of chalk. Presence of carbonic acid gas in air. Action of acid on carbonates, such as washing soda, etc.

8. *Action of Acids on Metals.*—Try the action of acids on lead, zinc, copper, tin, magnesium, iron, aluminium, &c. It will be observed that in many cases an inflammable gas is evolved; collect the gas and examine its properties. Burn the gas in air, collect the product and indentify it. The name "hydrogen." Reduction of oxides by hydrogen. Study of water.

9. These exercises afford much scope for the use of the balance. For example, in determining the properties of oxygen the weight and volume of the gas evolved on heating a certain quantity of potassium chlorate should be ascertained, and hence the weight of a litre of oxygen under (*a*) laboratory, and (*b*) N.T.P. conditions should be found. The number so determined should be compared with that previously found for air and checked by comparing the weights of oxygen and air held by a flask of known volume. Similarly the weight of a litre of carbonic acid gas should be determined. In the case of hydrogen the weight of one litre of the gas may be assumed. Such exercises as finding the volume at N.T.P. of hydrogen displaced from (*a*) dilute sulphuric acid by one gramme of zinc, (*b*) dilute sulphuric acid by one gramme of magnesium, (*c*) dilute hydrochloric acid by one gramme of aluminium, etc., etc., should be undertaken, and the weights of metals required to displace one gramme of hydrogen should be

calculated. From these and other quantitative exercises evidence will gradually be accumulated to bring home to the student's mind some of the fundamental generalisations, such as the indestructability of matter, the law of constant composition, and the notion of equivalent weights. In all the quantitative work class results should be collected, and after being fully discussed should be neatly tabulated in the note-books.

No attempt should be made to teach the Atomic theory, to write formulæ, or to give equations for reactions. The Course is intended to be an experimental one; but exercises in classification will arise under such headings as elements, compounds, oxides, carbonates, acids, alkalies, and so on.

The pupil will now be in a position to take up the study of one or more of the main branches of Physical or Natural Science. It is intended that the work of the third year should be devoted to at least one such branch, and that of the fourth to another.

(b.)—DRAWING.

FIRST YEAR SYLLABUS.

Elementary Freehand Drawing, with the addition of simple exercises in Design. Drawing of Objects in outline: pupils, who are qualified, should draw from real objects. Memory Drawing.

SECOND YEAR SYLLABUS.

Elementary Freehand Drawing, with the addition of simple exercises in Design. Drawing of Single Models and Real Objects in outline. Memory Drawing.

PRACTICAL GEOMETRY.—The instruction may be limited to problems involving simple constructions in the following:—

(1.) Constructions required in geometrical pattern drawing, simple tracery, and mouldings.

(2.) Construction of regular polygons—general method. Inscribed and circumscribed circles. Simple cases of rectilinear figures described in or about other rectilinear figures.

(3.) Circles—passing through three points—touching three lines. Tangent lines and circles to one or two circles.

(4.) The construction and measurement of angles. The construction of triangles from given data.

(5.) Construction of irregular polygons from given sides, angles, and diagonals. Similar figures—equal, enlarged, or reduced.

(6.) Construction of plain scales and scale of chords. Proportional division of lines, including the mean, third, and fourth proportionals. Reduction of polygons to triangles of equal area. Construction of parallelogram or square equal to a given triangle or other rectilinear figure.

PRELIMINARY COURSE OF EXPERIMENTAL SCIENCE.

SUGGESTED LISTS OF APPARATUS AND MATERIALS.

FIRST YEAR.

A.

(Apparatus required for each pair of Students.)

One half-metre scale, graduated in cms. and mms., and in inches and tenths.
One pair scissors.
One pair compasses.
Two set squares.
One retort stand (base 9 inches by 6 inches, height 2 feet), with three rings and clamp, to hold tubes up to diameter 1¼ inches.
One balance, to carry 250 grms., sensitive to 2 mgms.
One box weights, 200— ·001 grm. (cheap).
Two beakers, 3 inches high (medium form).
Two beakers, 4½ inches high (medium form).
One N.M. stoppered bottle, with narrow top stopper, 2 oz., or S.G. bottle 50 grammes.
Two iron tripods.
Two squares wire gauze, 30 mesh, 5 inches by 5 inches.
Two sand baths.
*Two Bunsens, No. 2 size.
*Two yards black rubber tubing for the Bunsens.
Two small flasks, 2 ozs.
Two rubber corks, 1 hole, (No. 4 size).
Two flasks, 12 ozs.
One specific gravity bridge.
One pestle and mortar (Wedgwood 3½-inch diam.)
One 50 cc. burette.
One single burette stand and clamp.

B.

(Apparatus required for each group of four Students.)

One metre scale, graduated in cms. and mms., and in inches and tenths.
Three rectangular wooden blocks, 2 inches by 2 inches by 4 inchss.
One pair inside and outside calipers.
One set (8) 2 cm. cubes of various woods.
One 4 cm. cube of ebony.
One 1 in. cube of ebony.
One 25 cc. pipette.
One 100 cc. graduated cylinder.
One 250 cc. " "
One pyramid (base an equilateral triangle of side, 2½ cms.; height, 5 cms.)
One prism (base an equilateral triangle of side, 2½ cms.; height, 5 cms.)
One cylinder (diameter of base, 3 cms.; height, 3 cms.)
One cone (diameter of base, 3 cms.; height, 3 cms.)
One sphere (diameter, 3 cms.)

These should be accurately made of box-wood or brass, preferably the latter.

* See note, page 82.

One bell jar and stopper, 9 inches by 4 inches.
One rubber cork, 1 hole, to fit the bell jar.
One triangular file.
One stout round-bottom flask, about 500 cc. capacity.
One rubber stopper, 1 hole, to fit this flask.
Two yards black rubber tubing, ⅛-inch.
One pinch cock (Mohr's), 2¼-inch.
One barometer tube.
One deal board, 36 inches by 4 inches by ½-inch.
One Boyle's law tube (unmounted).
One iron rod, 1 foot 6 inches long, 3-16th-inch thick.
One brass rod, „ „ „ „
One thermometer, engraved on stem, graduated up to 120° C.
One thermometer, engraved on stem, graduated up to 50° C. in fifths of degrees.
One thermometer, engraved on stem, graduated up to 250° F.
One Liebig's condenser, 12-inch.
One funnel, 2½ inches diameter.
One spun copper inside calorimeter, 1½-inch diameter, 3 inches high.
One stout glass pneumatic trough, 10 inches by 4 inches.
One opisometer.
One common hydrometer.
One Nicholson's hydrometer (brass).
One large cylinder for use with the Nicholson's hydrometer.
One Hare's apparatus (mounted).
One U tube, limb 2 feet by ⅜-inch.
One stop watch (not to exceed 6*s*.)
One iron saucepan (one gallon).
One rat-tail file.
One small curved pipette to fit into barometer tubes.

C.

(*Apparatus and materials required for general use.*)

One demonstration balance, similar to balance in A, but with pointer both sides.
One model Vernier for demonstration purposes.
Two micrometer screw gauges (superior).
One sliding calliper, with vernier (superior).
One ream squared paper (good).
One hollow cubic decimetre.
Five dozen 1 cm. wooden cubes.
Regular and irregular lumps of various common metals for density determination.
One litre flask.
One ½ „ „
One each pipettes (1, 5, 10, 20, 50, 100 cc.)
One 500 cc. graduated cylinder.
One brass bucket and cylinder for the Principle of Archimedes.
One steel tape measure.
One yard stick.
One specific gravity bottle and counterpoise.
One lactometer.
One doz. leaden spheres of various masses for pendulum experiments.
One cheap barometer (filled).

Four yards pressure tubing.
One Boyle's law tube on stand, with movable cistern.
One max. and min. thermometer (Fahrenheit).
One wet and dry bulb thermometer (Fahrenheit).
One Centigrade thermometer (mounted).
Half lb. thermometer tubing (1 mm. bore).
One paraffin, spirit, or benzene blow lamp.
Three rubber bellows as used with spray producers, for drying flasks, &c.
Three sets of cork borers (1-3) } Best quality.
One set of cork borers (1-10) }
Five lbs. glass tubing, sizes (1, 2, 3, 4).
Five yards rubber tubing, $\frac{1}{8}$-inch.
*Two batswing burners on stand 10 inches high.
*One Fletcher burner and one yard rubber tubing to fit.
One square of asbestos board, 1 foot by 1 foot.
Six dozen assorted wood corks.
Two dozen assorted rubber stoppers.
Six dozen test tubes, 5 inches by $\frac{5}{8}$-inch, and two dozen test tubes, various.
One reel very fine copper wire.
One lb. copper wire, various sizes, in long lengths.
One pair wire-cutting pliers.
Three empty Winchester quarts.
Three empty half Winchester quarts.
Six W.M. 16 oz. unstoppered bottles, fitted with corks.
One dozen test tube brushes.
Two test tube racks (10 holes).
Two dozen thermometer bulbs, with stem (1 mm bore).
Half lb. paraffin wax.
One lb. hyposulphite of soda.
Quarter lb. solid litmus.
One W.Q. methylated spirit.
One pint ether.
Half oz. magenta.
Ten lbs. mercury.
Two lbs. lead shot.
Four lbs. nitre.
Four lbs. sand.
Quarter lb. tin sheet.

SECOND YEAR.

APPARATUS REQUIRED IN A LABORATORY PROVIDED WITH THE FIRST YEAR'S APPARATUS AS DETAILED ABOVE.

D.

(Apparatus required for each pair of Students.)

One piece of platinum wire, 4 inches long.
One piece platinum foil, 2 inches by 1 inch.
Two crucibles and lids, No. 0.
One pair iron crucible tongs.
Two fire-clay triangles.

* See note, page 82.

Two clock glasses, 4 inches.
Two watch glasses, 2 inches.
Four cylinders, 6 inches by 2 inches, ground on top, foot with rim.
Four ground glass plates.
One deflagrating spoon.
One small beehive shelf.
One retort, stoppered, 8 oz.
One 4 oz. W.M. unstoppered bottle.
One rubber cork, 1 hole, to fit.
Eight oz. N.M. bottles with flat stoppers, labelled Hydrochloric Acid Dilute, Sulphuric Acid Dilute, Nitric Acid Dilute, Ammonium Hydrate Dilute, and Distilled Water.
Eight oz. N.M. bottle with rubber cork, labelled Caustic Soda.
Four oz. N.M. bottles with glass stoppers, and sand-blasted or enamelled labels as follows:—Hydrochloric Acid Concentrated, Nitric Acid Concentrated, Sulphuric Acid Concentrated.
Eight oz. N. M. bottle, fitted with cork and pipette, and labelled Litmus Solution.
Two funnels, 3 inches diameter.
Two thistle funnels, 9 inches.
One bone spatula.
One filter stand.
One test tube rack and test tube brush.
One each, box of red and blue litmus paper.
*Two star supports and chimneys for No. 2 Bunsens.
One apparatus for carbonic acid determination (cheap form).
Two evaporating dishes (No. 2 size).
One Woulff's bottle, 12 ozs., 2 necks.
One length hard glass tube (No. 9) closed at one end, 2 feet 6 inches long.
One rubber stopper to fit.
One screw cock, bottom part with hinge, ¼-inch.
One calcium chloride tube, 4 inches, U form.
One porcelain boat, 2 inches.

E.

(*Apparatus required for each group of four Students.*)

One earthenware or stout glass pneumatic trough, 10 inches by 4 inches.
Two tubulated bottles, 32 ounces—one, with one hole rubber corks in both holes, and the other with one hole rubber cork at bottom only.
One iron tube, 1 foot long, ⅝-inch internal diameter, closed one end.
One paraffin or benzene blow lamp, upright form.
One pair salamander crucible jackets, with fire clay triangle to fit.
One bell-jar and stopper, 9 inches by four inches, with one-hole rubber stopper to fit.
One Liebig's condenser, 12 inches.

F.

(*Apparatus and materials required for general use.*)

*One Ramsay burner.
One gross small rectangular fire-clay dishes (Morgan & Co.).
One thousand filter papers (qualitative), 10 cms.

*** See note, page 82.**

One hundred filter papers (qualitative), 20 cms.
Two iron tubes, 9 inches by ½-inch (internal diameter), closed one end.
Five canes hard glass tube, No. 9 size.
Five lbs. glass tubing, sizes 1, 2, 3, 4.
Two lbs. glass rod, sizes 1 and 3.
Two gross test tubes, 5 inches by ⅝-inch.
Half gross test tubes, 2 inches by ½-inch.
Three dozen boiling tubes.
Half gross hard glass tubes, 6 inches by ¾-inch.
*One muffle furnace, space inside muffle, 3⅞ inches wide, 3 inches high, 6½ inches long.
*One pair tongs for muffle.
One drying oven, 9 inches by 9 inches.
Six beakers, 6 inches high.
Six evaporating dishes, 5 inches diameter.
One iron tube, 1 foot 6 inches long, ¾-inch internal diameter, open both ends.
Twenty sheets coarse filter paper.
Ten yards rubber tubing, ⅛-inch diameter.
One dozen No. 0 crucibles.
One dozen funnels, 3 inches diameter.
One dozen evaporating dishes, No. 2 size.
One dozen 12-oz. flasks.
One dozen 16-oz. flasks.
One dozen test-tube brushes.
One filter pump with flask, funnel, cork, and plate.
Two packets filter papers to fit.
Six thistle funnels, 9 inches.
One dozen nests of beakers (Nos. 1-3), medium form.
Three pestles and mortars, various sizes.
Two funnels, 4-inch diam.
*One foot bellows and blow-pipe.
One yard platinum wire.
Platinum foil, 4 inches by 4 inches.
Three retorts, 8 ozs., with stopper.
One lamp glass and bung.
Specimens of quartz, fluor spar, selenite hæmatite, calcite, china clay, bauxite, felspar, mica, galena, cinnabar, iron pyrites, tin-stone, copper ore, and native sulphur, in W.M. bottles.
Two lbs. alum.
Five lbs. iron turnings.
One lb. iron filings.
Two lbs. iron rust.
Quarter lb. yellow phosphorus.
Half lb. asbestos wool.
Four lbs. red lead (pure).
One lb. litharge (massicot), pure.
Two lbs. sulphur.
One lb. manganese dioxide.
Four lbs. potassium chlorate.
Two lbs. potassium permanganate
Half lb. magnesium oxide.
One lb. zinc oxide.

*See note, page 82.

Half lb. copper oxide (powder).
Half lb. mercuric oxide.
Five lbs. common salt.
Two lbs. copper sulphate.
One lb. green vitriol (commercial).
Three lbs. rock salt.
Two Winchester quarts hydrochloric acid (commercial)
Two Winchester quarts nitric acid (commercial).
Two Winchester quarts sulphuric acid (commercial)
One lb. caustic soda.
,, ,, potash.
Two Winchester quarts ammonium hydrate.
Two lbs. quick lime.
Three lbs ammonium chloride.
Five lbs. chalk.
Four lbs. marble.
One lb. carbon.
Five lbs. washing soda.
Half lb. magnesium carbonate (heavy).
One lb. copper ,, (pure).
One lb. lead ,, ,,
One lb. zinc ,, ,,
Half lb. zinc foil (pure).
Five lbs. zinc, granulated.
Two lbs. zinc sticks.
One lb. granulated tin.
Quarter lb. aluminium foil.
Quarter lb. magnesium ribbon.
Two lbs. copper turnings.
Quarter lb. copper foil.
One lb. dry granular calcium chloride.
Half lb. copper oxide, granulated (pure).
One lb. borax (crystalline).
One oz. turmeric.
Four lbs. sand.
One lb. plaster of Paris, }
Quarter lb. water glass, } for making air-tight joints.
A supply of methylated spirit and paraffin or benzene (to be obtained locally).

N.B.—*All materials should be kept in carefully labelled bottles.*

LIST OF APPARATUS ADDITIONAL TO SETS D, E, AND F REQUIRED FOR THE SECOND YEAR'S COURSE IN A LABORATORY NOT PROVIDED WITH THE APPARATUS FOR FIRST YEAR'S COURSE.

G.

(Apparatus required for each pair of Students.)

One retort stand (height two feet), with two rings and clamp.
Two beakers, 3 inches high, }
Two ,, 4½ inches high, } medium form.
Two iron tripods.

Two wire gauzes, 5 inches square.
Two sand baths.
Two Bunsens (No. 2 size) and rubber tubing.
One 8 oz flask, with 2 hole rubber stopper.
One 12 oz. flask, with 2 hole rubber stopper.
One 12 oz. flask, with round bottom.
One earthenware or thick glass pneumatic trough.
One 50 cc. burette and stand.
One 25 cc. pipette.
One triangular file.
One rat tail file.
One Mohr's pinchcock, 2¼ inches.
One Centigrade thermometer.

H.

(Apparatus required for each four Students.)

One balance 250 grammes sensitive to 2 mgms. with full load.
One glass case for same.
One box wts. 100—·001 grm. (superior).
One earthenware or stout glass pneumatic trough, 10 inches by 4 inches.
One bell-jar and stopper, 9 inches by 4 inches, with one-hole rubber stopper to fit.
One Liebig's condenser, 12 inches.

J.

(Apparatus and materials required for general use.)

Two litre flasks.
Two half litre flasks.
One 250 cc flask.
One 100 cc. flask.
One each pipettes (1, 5, 10, 20, 50, 100 cc.).
One pipette rack or stand.
Five 500 cc. graduated cylinders.
Five 250 cc. graduated cylinders.
One 100 cc. graduated cylinder.
Three sets cork borers (1-3), }
One set cork borers (1-10), } best quality.
Ten yards rubber tubing, ⅛-inch.
*One Fletcher burner and tubing.
Six dozen assorted wood corks.
Two dozen assorted rubber corks.
One reel copper wire.
One lb. copper wire, various sizes.
One pair wire-cutting pliers.
One lb. paraffin wax.
Quarter lb. solid litmus.
Half W.Q. methylated spirit.
One pint ether.
One pint benzene.
One pint paraffin.
Four lbs. sand.
Four lbs. nitre.

* See note, page 82.

NOTE.—In schools not supplied with coal gas, the items marked with an asterisk are unnecessary; to replace them the following are suggested :—

Sets A and G.—Two spirit lamps, 4 oz.

Sets B and H.—One R. Lang's improved 3-flame spirit lamp.

Set E (additional).—One paraffin or benzene blow-lamp, upright form. One pair salamander crucible jackets, with fire-clay triangle to fit.

Sets C and J.—One Swedish lamp (paraffin)—diameter of grid, 6½ inches. Two German Petroleum boiling stoves—2-inch wick, single burner.

(3.)—PHYSICS.

GENERAL REMARKS.

The courses in Physics are designed not only to extend the pupil's range of knowledge of facts and principles, but also to provide him by means of exact measurement, with opportunities for examining more closely many phenomena with which his previous work has given him only an acquaintance.

In the preliminary course the instruction has been carried out in the laboratory with just such explanation as was necessary to an intelligent understanding of what was being done. Gradually, however, as the work becomes more advanced in character, the teacher will, while retaining laboratory instruction as the essential element, find it necessary to make use of the text-book and the lecture-room.

This should be cautiously done at first. There are two dangers to be guarded against. The pupils may be presented with new ideas at so rapid a rate that assimilation becomes impossible. On the other hand, they may come to regard the exercises as useless repetitions of what has already been done most satisfactorily by eminent investigators. To avoid this latter danger, the teacher should aim at bringing his class to a new exercise in the same mood and with the same intellectual interest as those in which the problem was approached by the first investigators.

Arrangement of Syllabus.

In drawing up syallabuses for such courses, the following considerations have to be kept in view by the teacher: (1) the capacity for assimilation of ideas to be expected from an average pupil at each stage of his progress; (2) the number of hours per session available for the subject; (3) expense and laboratory space required render practically impossible the duplication of any but the smallest items of the apparatus used; (4) under the limitations imposed by the foregoing, the course should cover as large a range of ideas as possible.

The ideal method would be to have the pupils working in the laboratory simultaneously at the same exercise, with the lecture-room work supplementing the practical work. Since it is impossible to secure this, the only available way in which a class of pupils can be taught advanced Physics in the physical laboratory is by a process of rotation of exercises.

Some hints, the results of experience, are given underneath, with a view to help the teacher to arrange his laboratory courses. These hints should be regarded as suggestions, and not as instructions.

Suggestions as to Course of Work.

A decision as to what exercises should be performed by the class, and the order in which they should be taken, must be largely the outcome of experience. The exercises need not necessarily be taken in the order given nor worked in the manner suggested; the order actually followed should, however, be, as a rule, from the less to the more difficult, but always with the evident limitation that the same piece of apparatus cannot be used for more than one exercise at a time. Every good teacher will, sooner or later, come to follow the results of his own experience.

Since the work in the lecture-room is free from the material limitations of the laboratory, it is expected to follow *a well-ordered course.* It should have constant reference to the experiments in progress in the laboratory, and ought to follow such a line of discussion as it would have taken if it had been supplementary to a well-arranged practical course, in which each experiment was worked simultaneously by the class, and one experiment followed another in regular succession. The "rotation process" of the laboratory will tend to break the sequence of the theoretical lessons and to make them unsystematic; but will succeed in doing so only when the organization is inefficient.

Laboratory Work.

It will be observed that by following the suggested arrangement of the laboratory course, some of the experiments will be ahead of the lecture-room work, and other experiments will be behind. This is unavoidable, if expensive apparatus is not to be duplicated; but it is not nearly so great a disadvantage for more advanced workers as it would be for beginners. At first the pupils may find the proposed method of working somewhat more difficult than if each experiment were carried out simultaneously by the class. Very soon, however, the pupils will be found to have grasped readily what is to be done, when set before a fresh experiment with but few instructions.

With a class consisting of twenty pupils working in pairs, the ten exercises in operation at any one laboratory lesson would, therefore, as a rule, be all different from one another

At each laboratory lesson a pair of workers would, in rotation, work one exercise, so that, by the end of ten lessons, a new batch of exercises would require to be provided. The teacher should keep a book, in which the names of the pairs of pupils, with the title and date of the experiments performed by each, are duly tabulated, like attendances in a register.

The columns of titles of the exercises carried out at the previous lessons would show at a glance what exercise comes by rotation to be next worked by any particular pair of pupils, and when a new batch of exercises is due.

Such a register would also enable the careful teacher to reduce to a vanishing quantity delays in a laboratory lesson caused by apparatus not being in working order, since he can tell some weeks beforehand when a particular instrument will be required for use.

For each exercise there should be prepared by the teacher a short paper of instructions, accompanied as a rule, in magnetic or electric work, by a diagram, and giving also a copy of the form in which the observations are to be tabulated by the pupil in his laboratory book. At the end of the lesson this paper should be returned to the teacher for use at the next lesson.

The date, the title of the experiment, and the form for tabulating results should all be entered in his book by the pupil before he begins an experiment. All entries should be in ink, each observation being entered immediately it is made.

The "curving" of the results should be carried out wherever possible.

Since every experiment is designed to discover *something*, the pupil should be taught to write down distinctly in words at the end of the record of his results, what is the conclusion to which those results point. If he cannot tell, it will be the teacher's business, by judicious questioning, to lead him to that conclusion.

For the sake of reference, it will be found a great convenience to number the pages of the laboratory book, and to reserve the first two pages for indexing the title and page of each exercise entered in the book.

When the teacher comes to revise some of the laboratory work, it is expected that he will not content himself with a mere repetition of the exercises already worked through, but will maintain the interest and value of the exercises by varying, when possible, the "unknown" to be obtained from the measurements.

THIRD YEAR SYLLABUS.

SUBJECT:—HEAT, LIGHT, AND SOUND.

HEAT.

Brief recapitulation of previous work in Heat.

Thermometry.

Test the fixed points of thermometers, making correction for barometric pressure.

Determine the boiling points of liquids, noting barometric height.

Observe variation of boiling point with strength of a saline solution.

Expansion.

Measure coefficient of linear expansion of solids.

Make a weight thermometer, fill with glycerine, and determine coefficient of apparent expansion of the liquid.

Find coefficient of cubical expansion of glass by means of a weight thermometer containing mercury.

Find the percentage change of volume of ice and of paraffin wax on melting.

Determine coefficient of expansion of air.

Verify Boyle's law for gases for pressures above and below that of the atmosphere.

Vapour Pressure.

Find the vapour pressure of such a liquid as water for temperatures (*a*) below 100° C., (*b*) above 100° C.

Determine the relative humidity of the air by means of a hygrometer.

Calorimetry.

Specific heat of substances by the method of mixtures.
Latent heat of fusion of ice.
Latent heat of vaporisation of water, and of alcohol.
Joule's experiments and the mechanical equivalent of heat.

Radiation.

Comparison of emission of radiant heat from surfaces at the same temperature.

Observations on the transparency of different thickness of such a substance as glass, for heat from a bright and a dark source.

LIGHT.

Principles and methods of photometry.

Reflexion: images formed by plane mirror; parallel and inclined plane mirrors; concave spherical mirrors and the images formed by them.

Refraction: index of refraction; total internal reflection, refraction by prism; convex and concave lenses and images formed by them. Principle of telescope and microscope should be illustrated by skeleton models showing construction.

Dispersion: composite character of white light; general theory of the spectroscope.

Practical Work in Light.

Find the candle power of a flame.

With plane mirror prove relation between angle of incidence and angle of reflexion; find relative positions of object and image. Observe images formed by two parallel plane mirrors; also when the mirrors are inclined to one another.

From positions of object and image, find radius of curvature of concave and convex mirrors.

Measure index of refraction for glass (1) by deviation of rays; (2) by measuring the real and the apparent thickness of the glass. Draw caustic of refraction; observe total internal reflection.

Measure approximate deviation produced by prism with various angles of incidence.

With convex and concave lenses find how sizes of object and image are related to their distances.

Find focal length of convex and concave lenses by (1) a distant source of light; (2) by use of plain mirror; (3) near source of light.

Observe through a prism the appearance of (1) a white strip laid on a dark background; (2) a dark strip laid on a white background.

Measure with spectrometer the angle of prism, and the index of refraction for, say, sodium light.

With spectrometer observe the solar spectrum, and note the readings of the positions of the most prominent dark lines. Compare with the positions of the bright lines shown by the vapours of various metals.

SOUND.

The exercises in Sound which the class can work in the Physical Laboratory are limited in their character by the serious difficulty that each pair of pupils would, as a rule, require a room for themselves. Such exercises as are possible in a practical course for a class would therefore need to be largely supplemented with demonstrations by the teacher assisted by the pupils wherever possible.

In a well arranged series of demonstrations the ideas to be conveyed will unfold themselves in an orderly manner, each observation or measurement leading on to the next, and the class ought to be able to draw most of the deductions from the observed facts.

It is suggested that the teacher should demonstrate the leading facts about sound somewhat in the manner indicated below.

Propagation of Sound illustrated.

1. A row of balls, similar in elastic properties to ivory; show effect of a collision by one, two, or three balls, on the others of the row.

2. Prove that a ball, like those just used, changes shape by a blow, by dropping it from a small height, and then from a greater, on to a stone slab where there is a patch of red paint thinned down with oil. Observe the sizes of the red marks on the ball.

3. Hang vertically from the ceiling a long spiral, about 3 cms. diameter, made of thin brass wire (about No. 22). Pull down the lower end and suddenly let go. The resulting impulse (a condensation) is easily followed by the eye as it travels along the spiral. Notice the difference in the nature of the reflected disturbance according as the reflexion takes place at the upper (fixed) end, or at the lower (free) end. How many times does the disturbance pass along the length of the spiral before it reappears as a condensation at the lower end?

In some such ways, the teacher can lead his class to the understanding of how sound is propagated by means of the elasticity of the medium; what is meant by a wave of sound, and by the length of the wave. By sending a small condensation or rarefaction along the spiral spring, and again a comparatively large condensation or rarefaction, the teacher can bring his class to see clearly that the length of such waves, and the extent of the motion of the individual particles are completely independent of each other.

4. Set the spiral spring vibrating as above, count the number of complete vibrations performed by the lower end, and also measure the length of the spring. The class should be easily able to calculate the speed with which an impulse passes along the spiral. The important point thus brought out can be enforced by varied numerical examples to be worked by the class.

5. A long cylindrical jar of air is suddenly struck at the mouth by the hand. The general nature of the resulting motion of the air in the jar ought to be now easy for the class to describe. How many cms. long is the wave?

6. Show that if a tuning fork is sounding, the prongs are in motion; for example, by making them touch the surface of water; or by touching a suspended pith ball: it can be shown that as the sound dies away, the motion of the prongs of the fork is getting smaller.

Resonance and Velocity of Sound.

7. A small A. fork, and a 5 oz. bottle with a mouth about an inch wide. A piece of glass about an inch-and-a-half long and an inch

wide slid gradually over the month of the bottle will serve to tune the air inside, until it resounds most loudly to the vibrating fork. Fix on the glass slip with wax.

8. Send a puff of breath across the opening in the mouth of the bottle: compare the pitch of the resulting note with the pitch of the note of the fork. The same point can be illustrated by taking a common earthenware jug, sending a puff of air across the mouth of it, and then showing that the air in the jug resounds to a note of that pitch sung or spoken by the voice. Many common examples will suggest themselves.

9. The velocity of sound in air can be measured approximately by use of a tuning fork of known frequency, say, 384 vibrations per second, and a glass tube about 60 cms. long and 3 cms. diameter, arranged so as to slide easily into a tall glass jar full of water. If the tube be gradually pulled out of the water, two positions of maximum resonance can be observed. Measure the lengths of the air column in the tube for each position, and find how the lengths are related to each other. A puff of breath sent across the open mouth of the tube in the two positions will show how the pitch of the resulting note is in each case related to the pitch of the fork. Calculate the velocity of sound in air.

10. Repeat the experiment, using carbonic acid gas in place of air in the tube, and this time pushing the tube into the water whilst searching for the positions of maximum resonance. Thus find how the velocity of sound in a gas is related to the density of the gas.

11. The same apparatus as in (9) above may be used for comparing the frequencies of two tuning forks, a large G. and a large C.; if one be of known frequency, the frequency of the other can be found.

12. The application of the principles of resonance to organ pipes should be shown by use of open flue pipes. The effect on the pitch of the note produced by closing the open end wholly, and partially, can be observed. Note the presence of harmonics.

Interference and Beats.

13. Use a bottle tuned to an A. fork as in (7) above, and twirl the vibrating fork slowly close to the opening in the mouth of the bottle.

14. Take two such bottles, each tuned to the A. fork. Set one bottle upright and the other horizontally, with the mouths of the bottles nearly touching. Bring down the vibrating fork horizontally so that the space between the prongs is opposite the opening in the upright bottle. Try also the effect when the opening in one of the bottles is covered with a slip of cardboard.

15. Intermittent interference, or beats, can be exhibited by two forks, for instance, one having a prong loaded with a small piece of wax. The use of beats in finding the difference of frequencies of two sounds, and also in the adjustment of two notes to unison should be pointed out. The relation between beats and record of notes, should be illustrated.

APPARATUS FOR DEMONSTRATIONS IN SOUND.*

Row of balls carried by threads on frame, or fitting in a groove on a board.

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* It is not considered necessary to give a list of apparatus for the other subjects.

Spiral 3 cms. in diameter, of thin brass wire (about No. 22) to be suspended by a hook from the ceiling above lecture table, and to be sufficiently long to come within about 12 inches of the top of table.

Tuning forks: two small of A.; one of C.; one of G.; one large of C. mounted on resonating box; one large standard G. fork, mounted on resonating box of frequency 384, which is stamped on box.

One 'cello bow.

Monochord.

20 feet of steel pianoforte wire, No. 22; same, No 24; same of brass wire, No. 22.

Two flue wooden organ pipes; one 21 inches long, the other 10½ inches. These should approximately sound C. in octaves.

Long flexible rope or thick cord.

Rod of mahogany about half-inch diameter and 6 feet long.

Clamp for the above, formed of two wooden blocks which can be brought towards one another by two screws.

Apparatus for use in Laboratory.

2 steel spiral springs, about 9 inches long, such as used for door-bell pull.

2 wooden laths accurately planed, 30 inches, by 1 inch, by $\frac{3}{16}$.

2 iron clamps for the same.

2 small camel hair brushes with which to obtain traces from the laths.

FOURTH YEAR SYLLABUS.

Subject:—MAGNETISM AND ELECTRICITY.

Introductory.

At this stage of the pupil's work be will have acquired some considerable skill in experimenting. By reason of his age and the experience he has had in manipulation he will be found capable of understanding and conducting successfully experiments with more elaborate and delicate apparatus than he has hitherto used. He will, indeed, not be satisfied to continue long at work on experiments whose bearings he can see at a glance. This very desirable sign of progress has, accordingly, to be met with a corresponding degree of development in the nature and complexity of the ideas presented to the pupil, both in the laboratory and the lecture room, if his interest in the work is to be sustained.

The suggested syllabus of practical work underneath is proposed as a result of experience of what pupils at this stage can successfully undertake. To the teacher of experience, again, the syllabus will suggest the corresponding work of the lecture-room.

During the first part of the session, whilst the simultaneous experiments (*a*), (*b*), (*c*) are in progress, there will be practically no distinction between laboratory and lecture-room work, for each experiment, usually short, will be followed immediately by a statement in the pupil's own words of the conclusion to be drawn from it.

FUNDAMENTAL LAWS AND EXPERIMENTS.

(*a*) Electrostatics : fundamental phenomena.
  Electrification by friction and by conduction; + and — electrification ; conductors and insulators; electrostatic induction.

(*b*) Magnetism : fundamental phenomena.
  Attraction of iron by a magnet: action of magnetic poles on each other ; directive property of a magnet ; magnetic induction ; lines of magnetic force, as shown by a short compass needle, and by iron filings.

(*c*) Voltaic electricity : fundamental experiments.

(The experiments (*a*), (*b*), (*c*) above can be carried out simultaneously by the class.)

Find the form of the lines of electrostatic force for various simple cases.

As an example, set up two tin cans on insulating stands, about 50 cms. apart, and so that their bottoms are about 15 cms. above the table. Connect each to one terminal of a Wimshurst machine. An exploring "needle" can be made with 5 cms. of stiff fine wire, a small pith ball being stuck on each end. This needle is suspended so as to hang, for instance, about the height of the middle of the cans. A suitable pointer, to move close to the large sheet of paper lying on the table underneath, can be formed from a very thin slip of ebonite, about the same length as the needle. This pointer can be made to follow the needle in its motions by attaching it to the latter by two equal and parallel lengths of cocoon fibre. Thus the lines of force are easily drawn on the sheet of paper. The needle is itself carried by cocoon silk fibre, fastened at the upper end to a long ebonite strip. If this strip be clipped between the jaws of a "universal stand," the necessary adjustments are easily made.

Properties of Magnets examined quantitatively.

Distribution of the force on a bar magnet by weighing the attraction of a small iron sphere.

Comparison of the force exerted by a short bar magnet in the A and B Gauss positions.

Prove that for one pole of a long steel strip, force (distance)^2 is constant.

Prove that for a point in the A or B Gauss position with respect to a short bar magnet, force × (distance)^3 is constant.

Comparison of the magnetic moments of short bar magnets by the method of inverse cube of the distances.

Prove that when a fine cord carrying a load W is displaced from the vertical through an angle θ, by a horizontal pull U, then $U = W \times \tan \theta$.

Comparison of the magnetic moments of short bar magnets by the method of tangents of deflexion.

Determine approximately the angle of dip by induction in soft iron (strip of tin plate).

Comparison of Electromotive Forces.

Find the E.M.F. of different voltaic combinations by help of quadrant electrometer and Clark cell.

Action of Galvanometer and of Electromagnet.

Compare the force exerted by a current in a coil without, and with, an iron core.

Action of Galvanometer examined quantitatively.

Determine how the force exerted by a current in a coil depends on (1) the number of turns of wire, (2) the mean radius of the coil.

Ohm's Law.

Verify Ohm's law by use of resistance box and mirror galvanometer.

Verify Ohm's law by use of quadrant electrometer and resistance box.

Compare the E.M.F. of cells, and combinations of cells, by use of resistance box and mirror galvanometer.

Find the calibration curve for low resistance galvanoscope by help of resistance box and steady cell.

Find the resistance of coils of wire by method of substitution.

Determine the resistance of steady cell by help of resistance box and tangent galvanometer.

Compare the E.M.F. of cells by use of resistance box and tangent galvanometer.

Wheatstone Bridge for comparison of resistances.

Find resistance of coils of wire by P.O. form of Wheatstone bridge.

Make approximate one ohm coil, and measure its resistance.

Find the specific resistance of the materials of wires by metre bridge.

Electrolysis.

Find the constant for tangent galvanometer by electrolysis of copper sulphate.

Thermo-electricity.

Thermo-electric currents: connection of galvanometer deflexion and temperature—difference of junctions for various couples.

Observe the existence of a neutral point, and inversion of current, by continuous raising of the temperature of a copper-iron thermocouple.

Electro-magnetic Induction.

Experiments on electro-magnetic induction with two coils; test effects of (1) magnitude; (2) direction of primary current; (3) relative position of coils; (4) iron cores of various diameters.

Distribution of magnetic force on a bar magnet by sliding a small coil step by step along the bar.

Determine the angle of dip by use of a coil of wire and mirror galvanometer.

Heating effect of Currents.

Determine the mechanical equivalent of heat by an electrical method.

(4.)—CHEMISTRY.

THIRD YEAR SYLLABUS.

Introductory. At the conclusion of the Second Year of the Preliminary Course, a student, from his own experiments, should be convinced of the truth of the *Law of Definite proportions*, and should fully realise the unvarying composition of a pure compound. He should understand what is meant by the term *Equivalent,* and should have appreciated the reciprocal nature of Equivalents (*e.g.*, that 12 gms. of magnesium, and 8 gms. of oxygen, are equivalent to 1 gm. of hydrogen; and also that 12 gms. of magesium are equivalent to 8 gms. of oxygen).

He should have a clear idea of the composition of air, water, and chalk, and should have arrived at a full general understanding of the nature of combustion.

Common Salt.—This substance has been already examined, and it has been found that by the action of sulphuric acid a gas is evolved, the solution of which in water is an acid, from which metals displace hydrogen. The gas may be further studied, as well as the acid solution.

Hydrochloric Acid Gas.—Action of gas on heated zinc and heated copper oxide; presence of hydrogen in the gas; examination of other products. Action of hydrochloric acid on *oxide of copper* (and other oxides), *litharge,** and *red lead*. (The products should in each case be examined, and the general nature of the action of an acid on a base further illustrated.) Comparison of the actions in cases of litharge and red lead; the *greenish-yellow gas* due to the *extra* oxygen of the red lead. Action of other *peroxides*, especially manganese peroxide.

Chlorine.—Its preparation and properties. Hydrochloric acid gas being hence recognised as hydrogen chloride, its quantitative examination should be commenced.

Quantitative Study of Hydrogen Chloride.—Action of sodium on the gas over mercury. Gas contains one-half its volume of hydrogen. (It is important to emphasize that this gives *no evidence* regarding volume of chlorine.)

Determination of the weight of a litre of hydrogen chloride, and of chlorine, and observation that the weight of 2 litres of hydrogen chloride, minus the weight of the contained litre of hydrogen, equals the weight of one litre of chlorine, as already determined. (The weight of a litre of hydrogen may be assumed.)

Comparison of densities of chlorine and hydrogen. Equivalent of chlorine.

[These experiments serve as a convenient introduction to the molecular conceptions of modern Chemistry. Reference having been previously made to the "*atoms*" of Dalton and the "*molecules intégrantes*" of Ampère in connection with the facts of chemical combination in definite and simple proportions, both by weight and by volume, and the uniformity in the physical behaviour of gases, the conclusions arrived at by Avogadro and Cannizzarro with respect to the complexity of these "atomic" individuals, should now be introduced and the conception of molecules fully explained. Symbols and very simple equations may be slowly introduced, but only in cases of well-studied changes.]

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* Use pure massicot.

Water.—Study of the behaviour of sodium towards water and the action of dry caustic soda on zinc would lead to the recognition of two separately replaceable quantities of hydrogen in water. Determination of the composition of water by weight and by volume (analytically and synthetically—hence formula (assuming density of water vapour). Difference between combining power of atoms of oxygen and chlorine.

Equivalent weights of metals which combine easily with chorine or with oxygen :—

Sodium.—By weighing sodium in small test-tube, and adding it in small pieces to dilute hydrochloric acid in a weighed basin.

Silver.—By reduction of silver chloride by hydrogen, or by converting silver into silver chloride.

The equivalents of zinc and magnesium previously found by replacing hydrogen in hydrochloric acid may be again recalled. (Students should appreciate that these equivalent weights stand on a direct experimental basis, and involve no atomic hypothesis or conception.)

Examination of Chlorides.—A number of Chlorides have been prepared during this work, and it is advisable to occasionally collect and correlate notes on these.

Nitric Acid.—Preparation has been already studied. It may be again examined, as well as the product left in the retort.

Action of Nitric Acid on metals—e.g., zinc, tin, iron, copper, magnesium. Oxidising action of nitric acid. Gases evolved should be studied. *Copper and nitric acid.* Gas collected over water; evidence of two gases: red, soluble; colourless, insoluble. Study of latter; combustion in this gas—effect of air or oxygen—quantitative action of oxygen. By study of products of combustion, presence of oxygen in the gas deduced. Heating of potassium or iron in the gas, and deduction that gas contains one-half volume of nitrogen. Density of gas, and establishment of formula.

Properties of the red gas. Composition deduced from previous work (*i.e.*, formula of nitric oxide and reaction with oxygen). *Zinc and nitric acid.* Production of gas which does not yield red fumes with air. (Use 15 per cent. solution of nitric acid.) Collection over water (slight solubility should be observed). Properties of gas, and difficulty of obtaining in state of purity by this method.

Evaporation of product formed by action of zinc and nitric acid, and heating with lime—smell of ammonia—hence a reduction product of nitric acid.

Examination of ammonia—solubility—combustion in oxygen—composition from decomposition by chlorine, and density.

Formation of salts of ammonia—ammonium chloride—sulphate—nitrate. Heating of ammonium nitrate—formation of gas, obtained previously by action of zinc and nitric acid. Properties of this gas—density—and composition from decomposition by potassium or sodium.

Heating of metallic nitrates, as copper nitrate, lead nitrate, &c.. and study of changes.

Composition of the three oxides, N_2O, NO, and NO_2, being known, the *Law of Multiple Proportions* may be illustrated.

Sulphuric Acid.—The action of the dilute acids on metals has been already investigated. The action of the concentrated acid, cold and hot, should be studied.

Action of concentrated Acid on Copper.—Recognition of gas evolved as that produced by combustion of sulphur, *i.e.*, oxide of sulphur. (Sulphuric acid therefore contains sulphur and oxygen: hydrogen has already been shown to be present.)

Properties of gas—acid solution—formation of salts—sulphites—properties of sulphites.

Examination of substances left in flask—*copper sulphide—copper sulphate*, &c.

Quantitative study of Sulphur Oxide. Sulphur burning in air or oxygen produces no change in volume—density of gas—these suffice to establish formula (with S=32). Preparation and examination of octahedral, prismatic and plastic sulphur. Density of each. Observation of time changes. Examination of the gas produced by burning each variety in air or oxygen. Determine whether equal amounts of the same gas are produced by burning equal weights of each variety in a closed volume of oxygen and opening under water.—Preparation of *sulphur trioxide*—the solution of this is *sulphuric acid*—formula of sulphuric acid. This may be verified (or at least supported) by determination of weight of sulphate produced from a known weight of an oxide.

Illustration of manufacture of sulphuric acid—action of the oxides of nitrogen.

Sulphides.—Heating of copper (powder or filings) with sulphur until constant weight is obtained. Similar experiment with *very fine* iron filings—examination of products—action of acid—examination of gas evolved. (Combustion of gas suggests sulphur and hydrogen).

Production of *Sulphides*. Use of gas in detection and separation of salts. Quantitative examination. Decomposition by heated tin (most easily effected in tube drawn out at both ends containing tinfoil, and afterwards opened under water), and density.

Action of acids on sulphides compared with action on oxides, and equations used.

Study of the Metals. Results obtained in the previous work should be collected under each metal, and only the gaps should now be filled in. Students should be familiar with the formation of insoluble salts by precipitation, and should be able to recognise any of the metallic and acid radicles included in the following list. Mixtures will not be given for analysis.

Sodium.—Hydroxide, carbonate, chloride, nitrate, sulphate. Recognition by flame test.

Potassium.—Hydroxide, carbonate, chloride, nitrate, sulphate. Flame test.

Ammonium.—Hydroxide, carbonate, chloride, sulphate nitrate. Recognition by volatility and evolution of ammonia.

Calcium.—Oxide, hydroxide, carbonate, chloride, sulphate. Recognition by insoluble carbonate (but soluble sulphide, flame test and slightly soluble sulphate.

Zinc.—Oxide, carbonate, chloride, sulphate, sulphide, nitrate. Detection by behaviour of oxide on heating, and by sulphide.

Iron.—The two sets of salts obtained from iron should be studied. Sulphate and nitrate form examples yielding green and brown hydroxides. The case of conversion from green to brown by atmospheric effect suggests a difference of oxidation—ferrous and ferric hydroxides—ferrous and ferric salts—mode of conversion from one to other by oxidising and reducing agents, *e.g.*, nitric acid and hydrogen (by zinc)—*sulphates, chlorides.* Detection of salts of iron by precipitation of ferric hydroxide.

Copper.—Oxide, sulphate, chloride, nitrate carbonate, sulphide. Precipitation of hydroxide and conversion to oxide—effect of heat on chloride—*cuprous chloride*—formation also from copper and cupric chloride. Cupric and cuprous salts—reduction of copper oxide.

Detection of copper by colour of solution; deposition of metal; dry test, and insoluble sulphide.

Lead.—Oxides, litharge, red lead—chloride—sulphate—nitrate—carbonate—sulphide. Reduction by charcoal; extraction of lead. Detection by chloride, and by dry test.

FOURTH YEAR SYLLABUS.

Introductory.

The course of work which is outlined in the following syllabus will, it is hoped, form a fitting conclusion to the study of Chemistry in Secondary Schools. The feature of the syllabus is the great stress which is laid on the thorough study of typical substances, processes and changes.

By a thorough investigation of the chemical constitution of some well selected compounds, the student will become acquainted with the most important methods in chemical research, and the necessity for care and skill in manipulation will be clearly impressed upon his mind. The educational value of such work will largely depend on the way the problem is presented to him and every effort should be made by the teacher to use such investigation as a means of training in scientific method rather than as a mere test of manipulative skill. The syllabus provides scope for the skilful and enthusiastic teacher; thus in dealing with tin and aluminium the influence of minute variations in the composition on the properties of alloys forms an exceedingly interesting side issue. In dealing with silver the subject of photography would naturally arise. When the students have from their own experimental work arrived at the formulæ of such substances as carbon dioxide and crystalline copper sulphate, it is hardly necessary for them to investigate the composition of every new substance they may have to deal with, for, having learnt the principles and methods by which the compositions of substances are determined by chemists, they will be able to appreciate the work of others, and to use without further question results accepted by common consent among chemists.

Recapitulation.

At the beginning of the fourth year it would be well to recall the previous work in regard to the densities of elementary and compound gases ($H = 1$ or $O = 16$), the meaning of the terms *at m*, *atomic weight*, *molecule*, *molecular weight*, and the full bearing of *Avogadro's Hypothesis* and *Gay Lussac's Law of Volumes*. The pupils following this course are expected to have a competent knowledge of the matter of the preceding courses.

Diffusion.

Demonstration experiments on the diffusion of gases and statement of *Graham's Law* should at this juncture prove of considerable interest, and should lead to an elementary consideration of the *kinetic theory of gases*.

Atomic weight of Metals.

It should be pointed out that although much was learnt about the equivalent weight of metals no determination of their atomic weights was made in the third year course. To bring out the difference in the combining power of atoms of metals, careful experimental study of the replacement of hydrogen in sulphuric and hydrochloric or nitric acids should be undertaken with potassium and zinc or magnesium. The equivalent weights being previously known and an indication of the valency being thus arrived at, the atomic weights of the metals should be calculated. Reference should then be made to the cases of silver, aluminium, lead, &c. During this work the basicity of acids should receive consideration. Determination of the specific heat of metals of known atomic weight (zinc, lead, silver and aluminium). *Dulong and Petit's Law*. Application of this law to the determination of the atomic weight of metals (using nickle or antimony).

Determination of empirical formulæ gravimetrically.

Determination of the percentage composition by weight, and hence empirical formulæ, of carbon dioxide, sodium chloride, crystalline copper sulphate. This will involve the preparation of pure substances and the accurate determination of carbon as carbon dioxide, of chlorine as silver chloride, of copper as copper oxide, of sulphuric acid as barium sulphate, and of water of crystallisation The preparation, properties, and composition of carbon monoxide should receive consideration when dealing with the analysis of carbon dioxide.

Determination of Molecular Weights. Determination of vapour density and molecular weight of easily vaporised compounds such as water, carbon bisulphide, and chloroform. Summary of the work on the determination of molecular weights and formulæ.

Halogens. The comparative study of the halogens and their compounds with hydrogen and the metals affords an excellent opportunity for illustrating the existence of families of elements, Another typical family, such as barium, strontium, and calcium, should be considered briefly, and the *periodic system* dealt with in an elementary way.

Silicon Occurrence in nature—general properties of its important compounds.

Metals. Minute study of the important metals, silver, tin, and aluminium, in so far as they have not been already considered. Occurrence of metals in nature and the principal methods for obtaining them from their ores, namely, (*a*) Reduction with carbon, (*b*) electrolysis, (*c*) substitution of one metal for another, (*d*) partial oxidation of sulphide and mutual reduction. Illustration of those processes by reference to the more common metals—details of manufacture not required.

Analysis.

Qualitative.—Pupils should be able to recognise any of the metallic and acid radicles studied in the course.

Quantitative.—(1.) *Gravimetric.*—Five typical gravimetric determinations included above.

(2.) *Volumetric.*—Preparation of Standard solutions of sodium carbonate and sulphuric acid—use of indicators—determination of acids and alkalies—use of permanganate of potash—standardisation by ferrous sulphate and measurement of ferrous and ferric iron: Volumetric estimation of chlorides by silver nitrate.

Organic Chemistry.

Distillation of sawdust.—Separation and identification of acetic acid and methyl alcohol in distillate.

Acetic acid.—Study as a type of fatty acids; basicity; preparation of sodium acetate leading to preparation of methane (type of paraffin series); statement of constitutional formula for acetic acid.

Methyl alcohol.—Study as a type of primary alcohols; analogy to water shown by action of sodium; action of phosphorus and iodine—preparation of methyl iodide (type of alkyl halogen compound); action of sulphuric acid and oxidising agents on methyl or ethyl alcohol.

Paraffins.—Production of methane (i.) as above, (ii.) by reduction of methyl iodide by zinc-copper couple. Synthesis of ethane by action of sodium on methyl iodide.

Historical Chemistry.

During the whole course endeavour should be made to interest the pupils in the work of the great chemists. Thus during the elementary course the work of Priestly, Lavoisier, Black, and Cavendish, may be referred to. In the third and fourth year courses many opportunities occur for further references to these chemists, and for adding some account of the work of Davy, Dumas, Dalton, and Graham. At the end of the fourth year, a student should have an idea of the general history of chemistry during the eighteenth and nineteenth centuries, and should be familiar with the chief work of the chemists mentioned above.

APPARATUS REQUIRED FOR THE THIRD YEAR COURSE IN CHEMISTRY.

These lists will serve as guides only; the exact requirements will depend on the present laboratory equipment of apparatus and stock of materials in each school.

(a.)—For every two students.

Basins, evaporating, 2½ inches, 3½ inches.
Beakers, 3 inches, 4 inches—2 each.
Blow-pipe.
Bottles, supply of N.M. for ordinary bench reagents.
Bottle, W.M. 8 oz., with thistle funnel and delivery tube.
Charcoal, hard—one piece.
Crucibles and lids, No. 0 and 2.
Crucible tongs.
Deflagrating spoon.
Desiccator.
Earthenware trough.
Files, triangular and rat-tail.
Fireclay triangles—2.
Flask, 8 oz., with 2-hole rubber stopper.
Flask, 12 oz., " " , round bottom.
Flasks, 8 oz., conical—3.
Funnels—2.
Funnel stand.
Gas jars—3.
Glass tube, hard, ¼-inch bore, 1 foot long—2.
Iron gauze, one piece 5 inches square.

Litmus papers, red and blue—one box of each.
Platinum wire—4 inches.
Porcelain boat.
Retort, 8 oz., with receiver.
Retort stand, with 2 rings and clamp.
Rubber stoppers to fit hard glass tube, one hole—2.
Rubber tubing, ¼-inch—2 feet.
Sand bath.
Test-tube brush.
Test-tube stand.
Thistle funnels—2.
Tripod stand.
U-tube, fitted with 1-hole stoppers.
Wash bottle.
Watch glasses—2.

(*b.*)—*For every four students.*

Balance, sensitive to ·2 mg.
Measuring Cylinder, 250 c.c. (in 2 c.c.).
Weights, accurately adjusted—one box.

(*c.*)—*Stock apparatus.*

Accumulators—2, or Bunsen cells—4.
Blow-pipe (foot), and bellows.
Boiling-tubes—½ gross.
Crucibles—12 each size.
Drying ovens—2.
Evaporating basins—12 each size.
Eudiometer tube.
Files, triangular—6.
Filter papers, 10 cm.—2,000.
Flasks, 8 oz.—12.
Flasks, round-bottomed—12.
Flasks, 2-litre—2.
Flask, 2½-litre, wide mouth.
Glass rods—2lbs.
Glass tubing, assorted—6 lbs.
Glass tubing, hard—4 lbs.
Graduated cylinders, 500 c.c.—2.
Ignition tubes—60.
India rubber tubing, ¼-inch—6 feet.
India rubber tubing, to fit Bunsens used—6 feet.
Induction coil, small.
Measuring flasks, 1-litre—4.
Mercury trough.
Muffle furnace, with tongs.
Pestles and mortars—4.
Platinum foil, 2½ inches by 1 inch—6 pieces.
Platinum wire—2 feet.
Test tubes, 5 inches by ⅝ inch—2 gross.
Test tubes, 5 inches by ¾ inch—1 gross,

Test tubes, 2 inches by ½ inch—½ gross
Thermometers, reading to 200° C.—10.
Thistle funnels—6.
Tube for ammonia composition
Voltameter, water.
Woulff's bottles—3.

(*d.*)—*Chemicals.*

Ammonium carbonate—¼ lb.
Ammonium chloride—2 lb.
Ammonium hydrate—one W. quart.
Ammonium nitrate—2 lb.
Ammonium sulphate—¼ lb.
Antimony, powdered, ¼ lb.
Bleaching powder, 1 lb.
Borax—1 lb.
Calcium chloride, granulated—2 lb.
Calcium sulphate—2 lb.
Carbon bisulphide—half W. quart.
Caustic potash—2 lb.
Caustic soda—2 lb.
Common salt—5 lb.
Copper chloride—½ lb.
Copper nitrate—¼ lb.
Copper oxide—1 lb.
Copper sulphate—2 lb.
Copper turnings and foil—2 lb.
Ferric chloride—¼ lb.
Ferrous sulphate—2 lb.
Hydrochloric acid—three W. quarts.
Iron filings—3 lb.
Iron sulphide—2 lb.
Lead carbonate—½ lb.
Lead nitrate—¼ lb.
Lime—2 lb.
Litharge—2 lb.
Magnesium—2 oz.
Manganese dioxide—4 lb.
Mercury—5 lb.
Nitric acid—two W. quarts.
Phosphorus—¼ lb.
Potassium—¼ lb.
Potassium carbonate—¼ lb.
Potassium nitrate—2 lb.
Red lead—3 lb.
Silver nitrate—¼ lb.
Sodium—½ lb.
Sodium carbonate—3 lb.
Sodium sulphate—1 lb.
Sodium sulphite—¼ lb.
Sulphur—5 lb.
Sulphuric acid—four W. quarts

Tin—1 lb.
Turpentine—½ pint.
Zinc, granulated—1 lb.
Zinc carbonate—¼ lb.
Zinc oxide—¼ lb.
Zinc sulphate—1 lb.

ADDITIONAL APPARATUS REQUIRED FOR THE FOURTH YEAR COURSE.

(*e.*)—*For every two students.*

Burette, with stopcock.
Calorimeter.
Condenser.
Condenser-holder.
Distillation flasks, 200 c.c. and 500 c.c.
Platinum foil.
Potash bulbs.
Thermometer, reading to $\frac{1}{5}^{\circ}$ or $\frac{1}{10}{}^{\circ}$ C.
U-tubes, fitted with 1-hole I.R. stoppers—two.
Weighing bottle.

(*f.*)—*For every four students.*

Dropping funnel.
Separating funnel—small stoppered with long tube.
Vapour density apparatus.

(*g.*)—*Stock apparatus.*

Crucibles, bone ash—10.
Crucible, platinum—one.
Diffusion apparatus.
Filter papers, quantitative, 10 cms.—500.
Glazed paper, black and white—12 sheets.
Lead basins, small for work with H.F.—6.

(*h.*)—*Chemicals.*

Acetic acid—1 lb.
Alcohol, absolute—2 lb
Alcohol, methylated—one W. quart.
Aluminium chloride—½ lb.
Aluminium sulphate—½ lb.
Antimony, in lumps—2 oz.
Barium carbonate—¼ lb.
Barium chloride—¼ lb.
Baryta—¼ lb.
Bauxite, a specimen.
Bromine—¼ lb.
Benzene—2 lb.
Calcium, a specimen.
Carbon bisulphide, pure—1 lb,

Cassiterite, a specimen.
Chloroform, pure—¼ lb.
Chrome, alum—¼ lb.
Epsom salts—1 lb.
Ether—½ lb.
Ferrous ammonium sulphate, pure—1 lb.
Fluorspar—1 lb.
Iodine—½ lb
Iron wire, pure—1 reel.
Mercuric chloride—¼ lb.
Methyl alcohol—1 lb.
Methyl iodide—1 oz.
Methyl orange—1 oz.
Microcosmic salt—¼ lb.
Nickel, in lumps—2 oz.
Oxalic acid—1 lb.
Phenol phthalein—1 oz.
Phosphorus, red—¼ lb.
Potash alum—1 lb.
Potassium bichromate—2 lb.
Potassium bromide—2 lb.
Potassium chromate—¼ lb.
Potassium ferricyanide—¼ lb.
Potassium ferrocyanide—¼ lb
Potassium fluoride—¼ lb.
Potassium iodide—1 lb.
Potassium permanganate—2 lb.
Rock crystals.
Silver foil—1 oz.
Silver sulphate—½ oz.
Sodium acetate—½ lb.
Sodium silicate—¼ lb.
Stannic chloride—¼ lb.
Stannous chloride—¼ lb.
Strontium carbonate—½ lb.
Strontium chloride—¼ lb.
Strontium nitrate—½ lb.

(5.)—MECHANICAL SCIENCE.

INTRODUCTION.

General Remarks.

1. In considering the adoption of a syllabus of instruction in Mechanical Science, it is necessary to remember the customary division of Mechanics into the two sections of Dynamics and Statics; and to decide the order in which these shall be taken. The older and perhaps more usual plan is to take Dynamics before Statics; but partly because Statics is distinctly easier than Dynamics, and still more because it is more readily treated experimentally, it is now a common practice to take Statics before Dynamics, or, what is better still, to take them together. It is, for example,

quite easy to arrange a large number of simple and very instructive Statical experiments in the Resolution and Equilibrium of Forces, and in Machines; but it is by no means possible to do so in such sections of Dynamics as Velocity, Acceleration, Momentum and Energy. If then, the theoretical and practical lessons are arranged in the usual way, it will be found quite possible to give all the theoretical instruction in Resolution and Composition of Forces in a few class meetings, and to provide enough experiments to last the class for a much longer time; so that they may continue this subject in the laboratory while the teacher deals with such Dynamical subjects as Velocity and Acceleration in the theoretical class. Every good teacher will see how individual experiments by pupils in connection with the Parallelogram of Forces will help them to understand the Parallelogram of Velocities.

2. Similarly, with the Statical subject of Machines: sufficient theoretical instruction can be given in a few class meetings; and the experiments may be continued afterwards, during which time the teacher can deal with Momentum and Energy, and find more than one useful illustration in the working of such a machine as a pulley block. Generally speaking, Dynamics requires far more class teaching than Statics, while, as already stated, Statics can be very largely taught by individual experimental work in the laboratory. A satisfactory course in Mechanical Science will include both sections; but exactly how they shall be taken is a matter which every good teacher will desire to find out and settle for himself, and on which hard and fast regulations should be avoided.

3. The essential feature of this syllabus is that the subject is to be treated experimentally; and that the experiments are to be performed by the pupils themselves, wherever possible. Further, the method of "discovery" is to be preferred to that of "verification," so that, although the pupil may be told what is meant by the mechanical efficiency of a machine, he should discover for himself how it varies with the load; and although he may be told what is meant by the coefficient of friction, he should be left to find out by experiment the conditions under which it is a constant.

Apparatus.

4. The syllabus is also arranged on the understanding that as a rule the whole class will do the same kind of experiment at the same time. There are, however, many parts of Mechanical Science which cannot be so treated since they do not readily lend themselves to satisfying the conditions named: in such cases it is assumed that the teacher will perform the experiments before the class as demonstrations, allowing individual pupils to assist, wherever practicable. Atwood's machine, Hicks' ballistic balance, balls rolling down inclined planes, apparatus for measuring centrifugal force, and fly wheels, are necessary parts in the equipment of a Mechanical Laboratory: and are practically the only means of doing experimental work in such fundamental parts of Mechanics as the relations between force, mass and acceleration; in momentum and energy. But school laboratories can scarcely be expected to contain more than one example of each of such expensive pieces of apparatus; if, indeed, they can secure that: and it is, therefore, necessary to restrict the use of apparatus of that character to demonstrations by the teacher, and to individual work by advanced pupils. The difficulty of giving beginners any concrete

notion of such parts of Dynamics as acceleration, momentum and energy will be appreciated by all teachers; and any means which can assist in doing so should always be adopted, especially as they are of such vital importance.

5. For reasons already stated, the details in the syllabus given later are restricted to such work as can be undertaken in a school laboratory, with fairly simple and sufficient apparatus, so that the whole class may work at the same kind of experiment concurrently. The syllabus is intended to provide for two years' school work, and to be suggestive rather than definite, in order that teachers may be free to work out their own ideas, and to adapt the course to the special conditions of their own school. For this reason, no attempt is made in the syllabus to distinguish between subjects to be taught theoretically or practically: it is assumed that the theoretical lesson will be regarded as supplementing the practical work rather than as antecedent to it. Sufficient has already been said to show that this will not always be possible.

Certain sections of Mechanics, such as projectiles, impact, &c., are omitted as being outside an elementary course; and for the same reason the more advanced treatment of subjects included in the course will not be expected.

Accuracy.

6. A word or two is desirable as to the degree of accuracy to be expected in the experiments. Very much of the work is in a sense qualitative rather than quantitative, as for example, the relation o the effort to the load in a machine, and its friction and efficiency; again, the value of the coefficient of friction between two plan. surfaces will be found to vary considerabl with the same piece of apparatus, according to atmospheric and other changeable conditions. On the other hand, the value of many of the experiments lies in accurately recording and measuring the observations and results, and the degree of accuracy, especially when verifying laws, is all-important. As a rule, a high degree of accuracy is only obtainable from carefully constructed and expensive machines; and as an essential feature of the course suggested is that the apparatus should be simple and inexpensive, the problem for the teacher is how to combine these qualities with sufficient accuracy.

With most of the apparatus, the chief difficulty will be found in eliminating friction, and in obtaining spring balances reading to sufficiently small units. Apart from these, it will be found that inaccuracies are more often due to careless observation and measurement or drawing on the part of the student, than to faults in the apparatus. Generally, there is no reason why the same degree of accuracy should not be obtained as in similar work in Physics.

7. With reference to the time to be given to the work of the course, three hours weekly is the minimum time, of which it is desirable that two hours should be given to laboratory work. If an additional half-hour or hour can be given to the working of examples, it will be foun of considerable service.

Laboratory Work.

8. The syllabus assumes that in the laboratory lessons the pupils will work in pairs, and that the observations made will be entered neatly in the laboratory note book in ink at the time of working the experiment. In all cases it is desirable to make an outline sketch of the machine or apparatus used, and wherever possible, to plot the results on squared paper, and to draw the "curves." A

useful laboratory book is one having the ordinary line ruling on one side of the page, and one-tenth of an inch squares on the other. Measurements should be made in both metric and British units. While requiring neatness and accuracy in the work done and in the note book record, it is not desirable to give too definite instructions to pupils before beginning an experiment, or to insist too rigidly upon hard and fast methods of entering the results in the note books. It is hoped that teachers will endeavour to give to their classes the same scope for originality and individuality in their work as they will themselves exercise in using this syllabus.

NOTE.—*In revising the syllabuses of this subject, provision has been made for two types of school, which may adopt the subject, viz.*:—(1) *Schools from which Students pass, after leaving the Secondary School, into business, and* (2), *Schools preparing students for a University career. Separate syllabuses are set out for each in the 3rd and 4th year courses, and considerable latitude will be allowed in the application of these syllabuses, but experimental work must form part of all.*

THIRD YEAR SYLLABUS.

Students are expected to have a competent knowledge of the subject matter of the preceding conrses, and to secure in this course an acquaintance with the principles of Mechanics by practical work.

GENERAL SYLLABUS.

Measurement of Force.
Resolution and Composition of Forces, including parallel and couples. Levers.
Velocity. Acceleration.
Newton's Laws of Motion.
Mass. Momentum. Impulse.
Work. Energy.
Centre of gravity. Stable, unstable, and neutral equilibrium

ALTERNATIVE SYLLABUS.

[*For Students preparing for the University.*]

Comparison of Forces. Resolution and Composition of Forces.
Moments and Levers.
Velocity and acceleration.
Newton's Laws of Motion.
Mass. Momentum.
Work. Energy.
Centre of gravity. Stable, unstable, and neutral equilibrium

A more advanced knowledge of the subject-matter of the first year course, with special regard to—

The pressure in a fluid.
The laws of floating bodies.
Specific Gravities.
Gaseous pressure. The barometer.
The pendulum.
Simple hydraulic and pneumatic apparatus.

Suggestions for Teaching the Third Year Syllabus.

Measurement of Force.

Preparatory to the use of spring balances and to the measurement of statical forces, an ordinary Salter's spring balance should be tested by hanging on weights, first increasing say from 1 lb. by ½ lb. or 1 lb., and then decreasing. The markings on the balance may be covered by a strip of paper, and the balance re-marked; or, as the extension of an india-rubber rod is sometimes used for the measurement of force, the relation between "tension" and "extension" in such a rod can be found. The rod should be of ⅜-inch or ½-inch diameter, and about 3 feet long, the ends tied in loops, the upper end hanging on a wall hook, with a scale pan on the lower end. A needle pushed through the rubber rod near each end and a metre scale fixed to the wall behind the needles will enable the extension for the different loads to be read. The results of the experiment with either the spring balance or rubber rod should be plotted on squared paper, and the curves drawn.

It will be useful to let the class determine the effect on the reading of the spring balance by a "suddenly applied load" as compared with one "slowly applied." By slightly lifting the weight on the balance with the hand, and then rapidly withdrawing the hand, the load will be "suddenly applied." If a strip of thin brass be bent round the face of the balance just under the pointer when unloaded, it will be moved down as the spring stretches, and thus enable the maximum reading of the balance caused by the sudden load to be easily recorded.

Resolution of Forces.

Specification and graphical representation of a force. Resultant and components. Parallelogram of forces. Triangle of forces. The best arrangement of apparatus for experiments is a board, about 12 inches by 10 inches, or a cheap half-imperial drawing board, fixed with its plane and long edges vertical, and having a light easy running pulley about 2-inch to 3-inch diameter fixed at each top corner. Three silk cords (about 1/16-inch diameter) have one end of each loosely knotted in a small brass ring, the other ends being free for tying to weights. Two of the cords are placed over the pulleys and the third hangs vertically with a scale pan attached. For the parallelogram of forces, the two given forces are represented by weights tied to the cords which pass over the pulleys, and weights are placed in the scale pan to represent the resultant. A piece of drawing paper having two lines drawn upon it at the given angle of the forces is placed behind the cords, and the weights adjusted until the lines and cords coincide. The paper is then pinned in position, the direction of the resultant marked upon it, and then removed, the parallelogram being completed by drawing. For the triangle of forces, the experiment is very similar. If the experiment is given as finding the conditions of equilibrium of any three forces, then the pulleys may be dispensed with, and small spring balances hung on hooks be used with the two upper cords, the vertical cord having a suitable weight attached. Or the board may be placed upon a table and three spring balances used. In experiments with spring balances, it is best to use larger boards, say of imperial size. Numerous experiments on the triangle of forces can be arranged with such boards and a few spring balances, weights and cord, the following being the most typical:—(*a*) Hanging a weight at one end of a vertical cord, and then pulling the weight to one side until the cord makes a given angle with the vertical, the "pulling" cord being horizontal, and the pull in each cord being found. (*b*) Suspending a weight to some point in a cord, the two ends of which are tied to points in the same horizontal line, the pull in each cord being found. In all experiments of this kind a spring balance is attached to each cord, the pull in which is to be measured.

The experiments should be extended to include the forces in the tie and jib of a simple model crane, the jib of which is attached at its lower end to a compression spring balance; and the tie to a small extension spring balance, a weight representing the load being suspended from the top end. Also a simple triangular roof truss can be made with two stout wood laths, loosely jointed at the apex, the lower ends being held together with a cord and spring balance, which acts as a "tie" and measures the pull when a weight is suspended from the apex. In all experiments of this type, the direction of the cords or members can generally be determined by marking upon a sheet of paper. In working out the results, accurate scale drawings should be made separately of the structure and of the forces, the "structure diagram" and the "force diagram" should be employed.

The step from three to four or more forces, and to the Polygon of Forces is an easy and natural one. The vertical board fitted with a pully at each of the four corners, and having thus five cords, is used to verify the polygon principle; and the model crane having the load cord (which represents the chain) attached to a point in the crane post somewhere between the tie and jib, forms a good experiment with four forces acting at a point.

The triangle of forces board is also used for forces not meeting in a point, by tying the three cords through holes near the edge of an irregular shaped piece of card. For illustrating the "funicular polygon," the larger board should be used with, say, three cords, each having a spring balance to read the pull, weights being tied to each of the two points representing the junction of two cords. The application of the funicular polygon to determining the reactions at the supports of a loaded beam, or the magnitude and position of the resultant of a number of parallel forces, can then be shown, the apparatus for the first experiment consisting of a horizontal wood beam suspended from its ends to spring balances which read the "reactions"; and in the second experiment of a simple lever turning on a fulcrum at its centre, and with weights suspended on each side to represent the parallel forces. The explanation of "couples" should be given in connection with parallel forces.

Centre of Gravity.

Experiments should be performed in balancing rods and circular, triangular and irregular shaped plates of wood or card on the thin edge of a rule or scale. The same plates should be suspended vertically by a cord from three corners or points, the direction of the cord being marked in each case on the plate, and their intersection shown to lie in the "balancing line," and to be the balancing point. Pieces of wood board shaped to triangles and parallelograms, and wood prisms, cones and cylinders should be placed upon a board, and the effect of inclining the board be ascertained. A stop on the board will prevent the solid sliding down, and by covering the board with a sheet of glass, the effect of friction in preventing the tendency of the solid to topple over will be eliminated. In this way, the position of the centre of gravity in the different solids will be found, and the chief properties of the centre of gravity and of stable and unstable equilibrium will be demonstrated.

Moments and Levers.

The meaning of "moment" and the propositions relating to moments can best be illustrated by two simple experiments. In one, a wood lever, divided along one edge into inches and turning about a central fulcrum of cone centres or knife edges, is employed, weights being suspended by strings on each side of the fulcrum. In the other, the polygon of forces board with four pulleys is used with an irregular shaped piece of card having cords from four holes near the edge of the card and passing over the pulleys with different weights tied on. The card is then pierced by a fine bradawl, which, being fixed into the board, forms a point about which the card can turn freely under the action of the pull in the cords. A sheet of paper having been previously pinned on the board, the directions of the cord are marked upon it for any convenient position of equilibrium. The paper is removed, and from each line of direction of a cord a perpendicular is drawn to the turning point. The moment of each weight is thus found, and the sum of the clockwise and anticlockwise moments are compared. A simple bell crank lever can also be made, having a spring balance to read the pull, and a screw for adjustment at the end of the short arm; the long arm being graduated in inches for weights suspended by cords; the lever turning on simple cone centres as a fulcrum. A simple straight lever with an end fulcrum, and with spring balances to represent and measure the upward forces, and weights hung on for downward forces, gives a useful additional experiment as introducing the centre of gravity of the lever.

As the laboratory work already described will occupy many class lessons, the teacher should introduce concurrently those sections of the subject which cannot well be dealt with by individual students. The following sections may be treated in this manner :—

Velocity : parallelogram of velocities : relative velocity.
Acceleration; falling bodies ; gravity.
Newton's Laws of Motion.
Mass : momentum : impulse.
Work : Energy.

Experiments on these subjects should, where possible, be made by the teacher, with the aid of the pupils if necessary ; and subsequently as occasion offers they may be repeated or extended by students who have completed the earlier parts of the syllabus of practical work.

In this way students are expected to secure acquaintance with Atwood's machine, Hicks' ballistic balance and apparatus for balls rolling down inclined planes, and should be able to express results obtained with facility on squared paper.

FOURTH YEAR SYLLABUS.

General Syllabus.

Elasticity, stress and strain.
Friction.
Work and Energy.

The study of machines.
The Flywheel. Centrifugal force.

As a result of this course, Students should have clear ideas on energy, momentum, and the law of "Conservation of Energy," and should know something of the properties of materials.

ALTERNATIVE SYLLABUS.

[For Students preparing for the University.]

Friction.
Work and Energy: conservation of energy
Machines.
The Pendulum: simple harmonic motion.

SUGGESTIONS FOR TEACHING THE FOURTH YEAR SYLLABUS.

Elasticity, Stress, and Strain.

It is desirable for students of Mechanics to have some notion of elasticity, and of the elastic properties of materials, and as the subject admits of simple and useful experimental work, it is included in this syllabus. The apparatus for the extension of the india-rubber rod already described in connection with the measurement of Force, provides an excellent experiment in elasticity. The extension of the rubber rod with loads increasing up to about 9 lbs. by increments of 1 lb. should be taken, and the readings repeated as the weights are removed pound by pound. Provided the maximum load is well within the elastic limit, the results will be very uniform, and students will readily discover that the strain varies with the stress, and thus be led up to understanding what is meant by a "modulus of elasticity" and its uses. Further experiments can be made with very thin wires of copper, brass, iron, and steel, which can be tested in extension to breaking, the arrangement being similar to that for the india-rubber, except that a more delicate means of measuring the extension is required, which can, however, easily be provided in some simple form of vernier. For the modulus of elasticity of a wire, a long length is required, and this is most conveniently arranged by placing the wire horizontally, one end being fixed to the wall or clamped on table, the other end passing over an easy running wood pulley of about 6-inch diameter, and then vertically downwards to the vernier and scale pan. The length of the wire can be supported on wood pegs.

The elastic laws can also be easily illustrated by loading strips of wood as beams. The beams can rest upon hard wood knife edges screwed to wood blocks abutting from a bench or table, the centre of the beam carrying a light metal stirrup from which the scale pan hangs. The deflection of the beam is measured by a pointer attached to and projecting from the stirrup and moving down against a short length of metre scale. An advantage of these elastic experiments is that they admit of the results being plotted on squared paper and the "curves" drawn, and that for wires they give examples for accurate measurement in the use of micrometer gauges and vernier callipers.

Friction.

Although usually regarded as advanced work, there is no real difficulty in an elementary treatment of friction, and as the apparatus required is quite simple, the subject readily lends itself to experimental work. The friction of simple pulley blocks for a series of loads should be determined; after which, the class should experiment on the friction between a wood slider and a wood board in order to discover that the coefficient is constant with the same two surfaces; that friction is independent of area, and that the tangent of the angle of friction is equal to the coefficient. The friction board may be of pine about 30 inches by 7 inches by 1¼ inches, with one side planed true and smooth, and with a small easy-running pulley at one end. The slider is also of pine about 9 inches by 6 inches by 1½ inches, one face being half cut away so that one area is twice the other. The board is placed horizontally upon a table with the slider at the end farthest from the pulley, a silk cord from the slider passing over the pulley to a scale pan. The slider is loaded with weights, and weights are placed in the scale pan until, when the slider is given a start, it moves along uniformly. The experiment is repeated with seven or nine different loads, and is performed a second time with the slider resting with its half area face on the board. For the angle of friction, the board is inclined by raising one end on weights, and the tangent of the angle of sliding found by measuring the height and base. Pupils should be made familiar with the terms normal pressure, limiting friction, and be given a proof of the fact that the coefficient is equal to the tangent of the angle of friction.

Machines.

The subject of "Work" is most easily dealt with in connection with machines, but there is no real reason why it should not be included at an earlier stage in the syllabus. If much Dynamics has been taken up to this stage, it will have been difficult to avoid some reference to work, although in a somewhat abstract way and without being able to measure it. Machines can be used for illustrations and measurements of work without reference to their properties as machines, and the following experiments may be performed at almost any stage of the syllabus. A load can be placed upon the machine, and weights to represent the "effort" or "force" be placed in a scale pan attached to the driving end of the machine, and so adjusted that, when given a slight start, the effort will overcome the load and raise it uniformly. Knowing the definition of "work," the student measures the distance moved by the "load" and "effort." and thus finds the work done in each case. An equally good experiment is to use an inclined board of wood, with a slider of wood from which a cord passes to a scale pan over a pulley at the top end of the board. The slider with weights upon it represents the "load," and the weights in the scale-pan the "effort" or "force." Then the effort acting through a distance equal to the length of the plane, lifts the load a distance equal to the height of the plane, and the distance being measured, the work in each case is determined. These experiments cannot fail to suggest to students that when work is done, some of it is expended in overcoming resistances such as friction, &c.; and that less work is done by the machine than is given to it.

In connection with their work with machines, students should be familiarised with the meaning and use of the "principle of work," both theoretically and practically; and of such terms as "agent," "power," "horse-power," "energy," "velocity ratio," "mechanical advantage," "mechanical efficiency," and the "friction" of machines. The machines used should include simple cord pulley blocks (one, two, and three sheaves), wheel and axle, Weston's differential chain pulley block, screw jack, and a simple windlass. The pulley blocks need no special arrangements, as weights hung upon the hook of the lower block represent the load, and a scale pan tied to the free end of the cord or hooked in the chain will represent the force or effort. A wheel and axle can be turned from wood and supported by a central iron spindle in blocks of wood to represent bearings which are screwed to ordinary wall brackets. The screw jack requires a wood pulley for the "effort" cord to be fixed to the head of the screw, a stout board on which the load is placed being fixed to the loose cap of the screw above the pulley. A simple windlass will only require to be fixed above the floor on a wooden stand, and to have a wooden pulley fixed to the driving axle for the "effort" cord.

The "velocity ratio" of each machine should be found by measuring the distance moved by the load and the effort or force, and this should be done at least three times; the theoretical velocity ratio being also determined by reasoning. For other experiments, the force or effort required to lift the load uniformly should be determined for seven or ten different and increasing loads, and the mechanical advantage, friction and efficiency should be calculated, the results being plotted upon squared paper in the form of curves.

LABORATORY FOR MECHANICAL SCIENCE.

It is not necessary to set apart a room for use as a Mechanical Laboratory, as nearly all the apparatus can be made movable, so as to be easily fixed on walls, or placed or clamped on tables, or hung on brackets, when required for class work; and at other times stored away in cupboards. Any well lighted room therefore, such as a Physics laboratory, or a Drawing class room, which contains some strong tables and provides plenty of wall space, can be readily utilised. Many pieces of apparatus are best arranged on walls; but if wall space is limited, an excellent substitute can be provided in a vertical framed or boarded wooden stand, firmly fixed to the floor or table top; while a stiff frame of three vertical posts, say of 3 inches by 3 inches and 8 feet high, with horizontal connecting pieces, so that the plan resembles an equilateral triangle, will be found convenient for hanging wires or machines, or for the clamping on of vertical boards. If a room can be set apart as a laboratory, then any oblong shaped room, well lighted and with plenty of wall space and a low ceiling, will meet all requirements. Pulley blocks and similar machines are most conveniently hung from hooks screwed into the ceiling beams, although long-armed wall brackets will serve equally well. Ordinary plain, strong, and movable tables, such as would be used in a Physics laboratory, should be provided, the size being about 8 feet by 4 feet for eight students working in pairs, or 8 feet by 2 feet 3 inches for four students. Fixed benches are not necessary, unless special provision is required for testing beams; and then they are best fixed well away from the wall in order to leave the wall space free. Cupboards or drawers for small apparatus should be provided.

It cannot be too strongly emphasised that objections to undertaking the course on the ground of having no suitable room should not be made, since, with a little ingenuity, and some extra trouble in arranging for and clearing away after each class, almost any class room can be used and useful work done.

SUGGESTED LIST OF APPARATUS REQUIRED FOR THE COURSE OF MECHANICAL SCIENCE.

The following list of apparatus is required for a class of twelve students working in pairs; and provides sufficient for all the students to be working at the same kind of experiment at the same time. The experiment need not be with precisely the same apparatus, as, for example, an experiment in extension may be with a rubber rod, or a spring balance, and in machines with a pulley block or screw jack. Apparatus such as weights, &c., for general use is given separately at the end of the list.

Extension.—6 lengths of ⅜-inch or ½-inch round white rubber rod 3½ feet long; needles about 3 inches long.

Measurement and Resolution of Forces.

Triangle, Parallelogram, and Polygon of Forces.—2 boards, 23 inches by 15½ inches, half-imperial size common drawing boards, each provided with 2 aluminium pulleys 2 inches to 3 inches diameter, with screw cone centres, 4 boards 31 inches by 23 inches Imperial drawing boards), two being provided with 4 pulleys, the other boards being used with spring balances.

The Imperial boards are also used for experiments on "tension in cords," the pulleys being removed, or separate boards provided. It would be convenient to have 6 boards without pulleys. Small screw hooks, on which to hang the balances, will be necessary.

A simple model of a crane.—This consists of a base board about 24 inches by 9 inches by 2 inches, with an upright post about 20 inches long, 2½ inches by 1½ inches. An ordinary compression balance reaching to 14 lbs. by 1 oz. is fixed on a wood block in the angle between the post and base board; and the wood jib 22 inches long 1¾-inch by ¾-inch tapering, is hinged to the balance and is provided with a small pulley (in a screw shackle) screwed in the top end. From a wire shackle a cord is taken to represent the "tie"; the pull being recorded on a spring balance reaching to 8 lbs. by 2 ozs. The angle of the jib is altered by passing the cord through different screw eyes in the vertical post.

Simple roof truss.—Two laths of wood, 3 feet by 1¼-inch by ½-inch, are fastened together at the upper end by a loosely-fitting bolt and nut; the lower ends being fixed to cross pieces about 7 inches by 2-inches by ¾-inch to give stability. A cord with a spring balance tying together the two ends represents the horizontal tie.

(The beam and lever for application of the funicular polygon are described under Moments.)

Centre of Gravity.

Two each, triangular, circular, and irregular shaped pieces of stout tin plate or thick cardboard, longest dimension about 10 inches; also 2 each pieces of wood board, 1-inch to 1¼-inch thick, shaped to oblong, triangular, and parallelogram, longest dimension about 12 inches; also 2 each square prisms, cones, and cylinders of wood and of same base and height (2½-inches by 3-inches base, 6 inches high)

For inclined planes the drawing boards already described can be used, weights being placed under one end to give the necessary inclination; or the friction boards can be used. Six sheets of glass about 12 inches by 5 inches will be required.

Moments and Levers.

Two hard wood levers, 3 feet to 4 feet long, 1½-inches by ¾-inch, top edge graduated into inches. One lever to have centred fulcrum and the other an end fulcrum. A simple fulcrum can be made with cone points and centres, and wood or metal bracket.

One 90° bell crank lever, of hard wood, with brass plates at joint and cone points and centres, with bracket on base board. Short arm of lever 4 inches, long arm 14 inches to 18 inches. Spring balance, 10 lbs. by 2 ozs., and screw with back pillar for adjustment.

One hard wood lever, 3 feet to 4 feet long, 1½-inches by ¾-inch, top edge graduated into inches, with screw eye at each end. Two circular balances, 15 lbs. by ½ oz., 6-inch diameter. Hooks for hanging balances to underside of shelf or to wall brackets.

Elasticity.

Testing Wires.—If verniers are used, then for each of 3 wires the requirements are, a simple wood or metal scale about 6 inches long, and vernier piece reaching to 1/100-inch or to 1/20 c.m. for clipping to fine wires, and two strong hooks in wall brackets or posts round which the measuring wire and testing wire can be twisted. A length of 20 inches from supports to vernier is convenient.

Young's Modulus.—Two wires arranged along longest walls of room. Ends of wires twisted round hooks in wall near ceiling or clamped to a bracket, wires passing round grooved wood pulleys 6-inches diameter and down to vernier and scale pin.

Beams.—For each of two beams, the requirements are two brackets or wood blocks abutting from bench or wall, with hard wood knife edges screwed on top face; a length of, say 6 inches, of metre scale screwed to wall or bench midway between brackets; a metal stirrup made of ⅛-inch plate with hole for hook of scale pan, and with wire pointer soldered to top edge. About 6 each wood strips for beams, say 3½ feet long, for 3 feet span, ½-inch by ¾-inch, ½-inch by ½-inch, ½-inch by ⅜-inch.

Friction.

Six boards of pine or of different woods, each 30 inches by 7 inches by 1¼ inches, with cross pieces on one side at ends and centre, and each with aluminium pulley fixed at one end, groove of pulley being for cord ¾ inch from surface of board. Six sliders of wood, each 9 inches by 6 inches by 1½ inches, and face half cut away in centre to 4½ inches wide, ½ inch deep. A screw eye in centre of one end of each slider ¾ inch from the face.

Six single pulleys (Gin pulleys) about 5-inch diameter of sheave, and cord.

Machines.

Cord pully blocks with an equal number of sheaves in top and bottom block; one with single sheave blocks, one with double sheave blocks, and one with three sheave blocks. A good size is to have 2-inch brass sheaves with grooves suitable for ordinary sash line.

One wheel and axle, turned from wood, wheel of 10-inch diameter, axles 5-inch and 3-inch diameter, and 4 inches long. Fix with central iron spindle, supported in wood bearings, on wall brackets. One single sheave pulley block with hook for cord.

One Weston's Differential chain pulley block of smallest size made. Length of chain for top block to be 7 feet from floor and bottom block to reach floor.

One tripod screw jack, 1½-inch diameter, frame of jack to be rigidly fixed to strong base board about 24 inches by 9 inches by 2½ inches, fixed head of screw to have wood pulley 6-inch diameter, loose head to have board about 9-inch diameter 2 inches thick for load. Small aluminium pulley as used for triangle of forces board to be fixed on wood pillar from base board at convenient height and distance for "effort cord."

For windlass, the smallest size single purchase windlass should be obtained: it should be fixed on wood framework about 2 feet from floor, the handle being removed and a wood pulley about 10-inch diameter for the effort cord fixed in its place.

APPARATUS FOR GENERAL USE.

Weights.—6 each of 56, 28, and 14 lbs., 12 each of 7, 4, and 2 lbs., 12 sets of 1 lb. to ½ oz., or 1 lb. to ·1 or ·05 lb. Half of the weights should be "bar weights" and half "ring weights."

Flat disc weights for use with hook rods are convenient for testing rubber rods or wires. They can be obtained in sets of 1 lb. to 1-10 lb.

Scale pans.—6 each of brass pans, 4-inch or 4½-inch diameter; and of tinned iron, 5-inch and 7-inch diameter; the pans having chains and hooks.

Spring balances.—12 small brass Sportsman's, 4 lbs by 1 oz., and 6 of 8 lbs. by 1 oz. Six improved spring balances, No. 1, 14 lbs. by 2 ozs. One Family balance, 7 lbs. by ½ oz., 5-inch dial. enamelled face. By giving instructions with order, the balances can be graduated to ·1 and ·05 lb., which is much more convenient than to ounces.

Rules.—6 wood metre scales, with inches and tenths on one side, metric scale on other side.

6 wood 12-inch rulers, inches and tenths, with one edge bevelled.

One spirit level (about 8 inches).

A supply of fine wire (about 1-32-inch diameter), iron, brass, copper; of silk cord, sash line, and thick card (millboard).

SPECIAL APPARATUS FOR DYNAMICS.

Atwood's machine.

Hicks' ballistic balance.

Apparatus for balls rolling down inclined plans and water clock with electrical connections.

Apparatus for centrifugal force.

Small balanced fly-wheel for energy experiments.

Simple pendulums.

NOTE.—When purchasing apparatus, teachers should satisfy themselves as to suitability and reliability.

(6.)—BOTANY.

THIRD YEAR SYLLABUS.

STUDY OF FLOWERING PLANTS ACCORDING TO ENVIRONMENT AND SEASON.

Method of Study. The method of study most suitable to become part of the daily life of the pupil is that which is based upon the relationship of plants to one another, to animals which affect their growth, to physical environment, and to the seasons.

Relationship of Plants to one another.

Plant associations, such as a forest and its undergrowth; a hedge and its climbers; a cornfield and its weeds.

Plants that grow singly in the district, that is, do not form colonies or definite associations.

Relationship of Plants to Animals.

Influence of mammals that prune by browsing, thus altering the external shape of bushes, trees, furze, and pasturage generally; similar action of rodents and other small mammals. Influence of insects that affect pollination, or that protect plants against the attacks of injurious insects. Influence of insects (both larval and fully developed) that injure plants, *e.g.*, the aphides on stems and leaves; and grub and wireworm at roots.

Relationship of Plants to Physical Surroundings.

Soil, moisture, temperature, and exposure including exposure to light and to prevalent winds) are the chief factors. Plant associations or societies are thus determined.

Plants specially associated with basalt, granite, lime, and other rock formations; with clay, loam, sand, or peat (turf) soils.

Plant societies in bogs, streams, and ponds.

Plant societies in pure sand, as on the dunes by the sea.

Plant societies noted under the relationship of plants to one another.

Influence of sea breezes; comparison everywhere between influence of sheltered and exposed situations.

DRAWING TO SCALE.

Students' drawings should be made to scale

Large plants may be drawn to scale of ½, ⅓, ¼, etc., to suit the size of paper in sketch book; but, in each case, the scale should be marked. When members of plants are drawn separately, they may be made to a scale of 2, 3, 4, etc., but, if possible, a uniform scale should be adopted for each plant; if it is necessary o show a stamen, seed, or other small part on a still larger scale, additional drawings should be made. In addition to the scale drawings a *memorandum of the actual measurements* should be given in the note-book.

TECHNICAL LANGUAGE.

With reference to the orders presented in the course, it may be explained that a knowledge such as may be obtained from a standard Flora is not required; the pupil is asked to make the simplest examination only so as to be able to say that one specimen has the characters of the rose, and another those of the daisy, and so on.

At the same time, the teacher is expected to demonstrate from actual specimens the characters to be studied in the classification of plants into orders; but the descriptions need not be burdened with superfluous technical terms when definite English terms are sufficient. It should be remembered that the study is one which may find expression in simple sketches which tell far more than the most accurate phraseology of the language.

EQUIPMENT.

(*a.*) *For Class Purposes*—

A six-inch to the mile Ordnance Survey Map of the district in which the field excursions are to be made.

A Flora of the British Isles.

Flower pots, seed pans, and suitable potting soil.

An optical lantern and a set of slides.

(*b.*) *For Pupils.* (*Each pupil*)—

A pocket note-book for field purposes; a sketch-book and note-book combined for outline and diagrammatic drawing and notes of student's own observations: two black lead pencils (a B.B. and H.B.), water-colours; one or two brushes for water-colours (or coloured pencils will serve), a sharp knife, a pair of mounted needles, a pair of small steel forceps, a millimetre rule, and a double planoconvex pocket lens.

NATURE CALENDAR.

Pupils should be required to keep a diary of events, such as the fall of the leaf, the first frost, the first appearance of flowers, etc. Such particulars as daily temperature, general remarks as to weather, "dull," "bright," etc., should also be noted.

As the School Year begins after the summer holidays, the present course should be commenced in August or September. Early autumn is an exceptionally good time to begin a course on observational Botany, as the chief events in the life-history of a plant throughout its year's growth may be easily reviewed at this season.

Preliminary Lessons on Living Plants.

As a preliminary, however, a start may be made by selecting one particular plant and devoting a lesson or two to its study, It is most important that the actual specimens used by the class be living rooted plants, growing under natural conditions or in pots. (It may be well to ascertain first by questioning what the pupils already know about a plant, and then to arrange or systematise this knowledge as a basis for further study).

Autumn Studies.

The pupils will be directed to observe and note the differences between that part of the plant's body which is in the soil and that part which is above ground; and by questioning and suggestion the class will be led to see that the *forms* assumed by the different organs are correlated with their environment and function.

(In these and the other lessons following, the necessity for *names* will constantly arise. Under such circumstances—that is, *when the necessity is really felt by the learners*—there need be no hesitation in making use of a suitable technical term.)

Study of Habit.

The study of a type will naturally lead to a comparative examination of other plants. If at all possible, these lessons should be given out of doors, where abundance of living subjects illustrating adaptability of form ("habit") to particular environment may be conveniently studied. In this connection the nature of the soil and conditions as to moisture, light, and shelter ought to be noted. The "habit" of different plants associated with one another in a marked off area ought to be worked out by the pupils.

Whenever possible attention should be directed to the sensitiveness of plants to certain external agents, especially to light pressure (as in twining and tendril-bearing plants), and to moisture; but all experimental work may be conveniently postponed until the early summer.

Advantages of Commencing Study in the Autumn.

After such preliminary work as the foregoing, the pupils may be led on to construct from direct observation, aided by obvious inference, the life history of a few typical plants throughout the changing seasons of the year. It will be found convenient to study in succession selected examples of the three great groups—Annuals, Biennials and Perennials (herbaceous and woody). At this season, fortunately, specimens may be obtained representing every phase of plant activity—seedling stage, period of vigorous growth and individual advancement, bud development, completion of seasonal growth and storage of surplus food, development of flowers, production and dispersal of seeds, preparation for winter's rest, and resting condition.

Study of Life Histories of Plants—Economy of Annuals.

Annuals.—Most of these have now passed into the "fruiting" stage, and it will be easily seen in such cases that growth has apparently come to an end. If, however search be made, annuals may be discovered at this season in all stages, from the seedling to maturity. Some will also be found with the seeds scattered and the plant dying. There should, therefore, be no difficulty in leading pupils to see that in annuals the early part of their season of activity is mainly devoted to individual growth and development, while the latter part is devoted to the production of young contained in seeds; and that after the dispersal of the latter the plant gradually dies.

Economy of Biennials.

The pupils may now be given the task of finding out the life-history of such a plant as the Turnip, Carrot, Hollyhock (or other type of Biennial conveniently at hand). At this period of the year it may be producing, or it may have already produced seed. Obtain plants only one season old and compare with those of two year old growth. Direct pupils to examine the root of the former and question them upon it. Sufficient evidence will be forthcoming to show that in Biennials the whole of the first growing year is devoted to individual growth and development and to the storing of surplus food in the root. Then there is a period of rest, after which the whole of the second year is mainly devoted to the production of young. During this period the reserves of food are withdrawn and used for purposes of growth. After dispersal of the seeds, the plant gradually dies.

Economy of Perennials.

Herbaceous Type.—In the same way lead pupils to interpret the story of the Perennial from what may be now observed in the field. Begin with an easily-studied herbaceous perennial. In the simplest cases (1) the flowering shoots have had the same history as annuals, but they are exceptional in that they arise from an underground stem instead of from a seed; (2) simultaneously with the growth above ground, new buds (for next year's shoots) have been developed underground; and (3) food has been stored in the permanent subterranean stem as a reserve for the spring use of the buds.

Woody Type.—Follow this up with the study of a typical woody perennial. Lead the pupils to discover and mark off on a selected tree the exact length of leafy shoot which they consider represents the result of the season's growth. (If such a tree as the maple, in which the twig ends in an inflorescence, is selected, it will be easy to compare the now fruiting branch with the annual plant and the shoot of herbaceous perennial previously studied. Pupils will readily recognise wherein it differs from the annual and agrees with the shoot of the herbaceous perennial.)

Note the formation of buds on the young shoot, and question pupils as to what they know concerning their nature and destiny.

When in the field or garden, draw frequent attention to the various methods of vegetative propagation such as bulbils, rosettes, runners, &c., and invite pupils to work out little problems in plant economy, such as :—"What becomes of duckweed during the winter ?" "How do pondweeds hibernate ?"

Review of Work and Comparison of Life Histories.

By much questioning and consultation of note-books, take the class over the whole ground of observation already recorded, and make the following facts quite clear :—

(1.) A plant is first of all concerned in building up its own body—that is, developing those organs that are directly concerned in its own welfare.

(2.) Having reached vegetative maturity, its chief concern is the welfare of the race, the continuance of which is secured by the production of young contained in seeds, or by the detachment of buds possessed of the power to lead a separate existence.

(3.) In plants that live for two or more years, further vegetative growth is secured for each year by the formation of buds that lie dormant during the winter.

(4.) In all biennial and perennial plants reserve food is stored for the feeding of the bud in spring, while in annuals all surplus food is stored in the seed.

Dispersal of Seeds.

The methods by which seeds are naturally distributed over the surface of the country ought to be, to some extent at least, studied at this period of the year. Once the pupils are interested in the matter they will make their own observations "out of school." Indeed, this is the kind of spirit that ought to prevail throughout the whole course. The pupils should be so thoroughly interested in the subject that they will always be on the alert to discover something new, and anxious to accumulate facts in their "Nature Calendar."

The Passage into Winter.

As autumn wanes, the leaves of deciduous trees change colour. The pupils should be encouraged to observe and note these changes. Leaf-fall is to be very carefully studied. By exposing the insertion of the leaf in section from time to time a few weeks in advance of the actual fall, the mechanical reason for defoliation will really be discovered by the pupils. The times of leaf-fall of the trees in the locality will be noted—(*a*) when the leaves begin to fall; (*b*) when the tree is bare of leaf.

The Beginning of Winter : Modes of Protection against Wet and Cold.

Winter Studies.

In early winter, close attention should be paid to the various methods adopted by plants to protect themselves against the trying effects of the weather, *e.g.*, the underground habit of main stem carrying the buds and containing the reserve food to feed these buds next spring; drying ("ripening") of twigs and protection of same by jackets of cork; covering of air-exposed buds often with dry tough scales; further protection by gummy secretions, &c., &c.

As the weather gets more severe, special attention should be given to the decay of the aerial shoots of herbaceous perennials, and to the protection these decaying members afford to the hibernating plant beneath.

A Winter Field-excursion.

During December or January the class should be taken out for a field-excusion and the vegetation studied at this, its period of lowest vital activity. Note, however, in sheltered places the large number of autumn seedlings making a brave struggle against the adverse conditions of existence.

Study of Dormant Underground Structures.

In the meantime some typical underground structures should be examined in the class-room. The following are suggested:—

(1.) Tulip or snowdrop bulbs and crocus corms. Each pupil to be supplied with three or four specimens of each kind; one of each kind to be thoroughly studied with dissecting knife and lens, and careful sketches made of the parts. Old plants showing the origin of the young bulbs and corms ought to be exhibited and demonstrations given upon them.

(If not done before, the iodine test for starch should be shown to the class. The pupils should thereafter be invited to discover whereabouts in the bulb or corm starch is stored, or whether, in fact, starch is present at all. Furthermore, if a microscope is available, starch-grains might be shown to the pupils in scrapings from the starch-holding tissues.)

Pot Culture for Bulbs, &c. for Convenience of Future Study.

After completion of above examination the class should be shown how to plant the remaining bulbs, &c., in pots or boxes of earth. Some so planted may be kept in the school, but pupils should be encouraged to plant duplicates at home and attend carefully to them until they pass into the flowering stage.

Sketches of the plants should be made at different stages of development.

Further Study of Underground Structures.

A rhizome and a tuber (potato will serve) should be examined externally, and in vertical section, and duplicates put down to "sprout." As in the last exercise, sketches should, of course, be made.

A biennial "root," such as turnip, carrot, evening primrose, &c., may be examined, sketched in vertical section, and a specimen planted in a box in order to study future development.

Special Points to note in the Study.

In all the above cases, particular care should be taken to see that the class clearly understands (*a*) the age of the structure, (*b*) the position and character of the bud or buds, (*c*) the whereabouts of the reserve food, and, if possible, (*d*) the nature of the reserve food.

The Twigs of Trees.—Study of these and comparison with Underground Structures previously examined.

Woody twigs may now be examined in detail with dissecting knife and lens. Let pupils sketch external features, showing shape and position of buds, &c. They should then be led to discover that there is a separable bark, covered externally with a thin layer of cork, and enclosing a cylinder of wood with medullary rays, connecting the pith with the bark. Direct pupils to study the connection between the buds and the supporting "wood" by cuts that split the stem and bisect the buds. Sketches should be carefully made, with the help of the lens, if necessary. It is important to let pupils discover the reserve food stores in winter twigs; the twigs of some trees show it (by the iodine test) very much better than others.

Resting Flower Buds.

Follow this work up by getting the class to examine twigs of early flowering shrubs or trees, such as currant, cherry, elm, etc. See whether they will discover the flower buds; it is very important that they should.

(Cuttings of willow and other twigs should now be placed in bottles of water to supply material for the study of the "opening of buds" in spring. Keep the bottles in the school-room.)

Study of Trees.

The foregoing exercise will naturally lead on to the study of *branching* in trees and shrubs; and this is the most favourable time of the year to begin. Pupils ought to be encouraged to learn to recognise trees by their winter appearance.

"Evergreen" trees and shrubs should have some attention about this time. The advantage of the needle-shaped leaves in pines may be indicated.

Examination of Planted Bulbs, &c.

Spring Studies.

Towards the beginning of spring the autumn-planted bulbs, &c., will have reached the flowering stage. Each pupil will carefully raise a specimen plant, wash the roots, and compare its present appearance with the sketches made of the same kind of "bulb," &c., in the autumn. By questioning, lead the class to realise that the flowering shoots have been feeding upon the stores of reserve food found to be present in the bulb last autumn, and to understand why the snowdrop, crocus, &c., are such early flowering plants.

Reasons for Early Flowering.

Study the flower itself with the class, and pay particular attention to the pollen-producing and seed-producing organs.

Exercise in Artificial Pollination.

Using the plants left untouched in plants or boxes, show the class how to pollinate the stigmas by means of a camel's hair brush, and then let each pupil pollinate a flower in the same way. Set the pollinated plants aside and let the pupils watch the gradual formation of the fruit. Sketches drawn to scale, and illustrating the development of the fruit, are desirable. The conditions of fruit development in the crocus will be an interesting variation from the normal.

"Home-work."—Watching the Bees pollinating early Spring Flowers.

Later, when the crocus and other spring flowers are open in gardens and on lawns, suggest to the pupils the exercise of watching to see how pollination is affected in Nature.

How the Microscope may be used with advantage.

If a microscope is available, pupils might be shown the pollen grains of the different plants examined. It will also give additional interest to this part of the course if a bee is caught, and the pollen found on its body examined under the microscope; the pupils should be asked to recognise the source of the grains.

Artificial Hastening of Twig Activity.

About this time, if not earlier, the twigs forced in bottles of water will be ready for study. Provide each pupil with a twig thus forced in its growth, and one taken fresh from the same kind of tree. Compare. Note difference in quantity of sap and, in particular, the ease with which the bark seperates from the wood in one of them. Introduce the word "cambium," and advise as to its meaning and importance. Question class as to the origin of the food upon which the young shoots are now feeding, and compare physiology with that of the bulbs and corms previously studied.

Examination of other Cultures.

Overhaul the other structures (tubers, roots, &c.), laid down to sprout, and if sufficiently advanced, distribute among pupils, and by questioning elicit their physiology of growth.

An Outdoor Class.

The beginning of spring is announced by the bursting of buds in our shrubs and trees. A bright day should be selected, and the class taken on a field excursion. Let pupils note all the "signs." A collection of twigs taken from different trees, &c.,

should be made, and in those with already opened buds the evidence of the flowing "sap" should be discovered.

Root-pressure and "Ascent of Sap."

Select a young tree or vigorous sapling, whose buds have begun to swell, and demonstrate to class the force of this spring run of sap by the usual root-pressure experiment.

The Evolution of a Shoot.

Once the bursting of bud has really set in, pupils should make a selection of one particular tree (maple is a good example), and prepare a series of sketches showing the gradual evolution of a twig from a bud.

The meaning of the peculiar ring-like scar seen at the base of the leafy shoots of trees will now be evident.

Seeds and Germination.

The study of seeds and germination will form a very important feature of spring work with the class. A series of types ought to be selected some weeks before they are really wanted, and a sufficient number sown in pots of fine earth, to supply specimens to the class.

(Attention must be paid to drainage and watering, and the pots kept in a moderately warm place.) It will be well, when studying a seed, to have a germinated specimen of the same kind in front of the pupil for comparison.

Physiology of Germination.

Some time and care should be given to the physiology of germination. The experiments need not be numerous, but they should be convincing. With the pots of germinated seedlings in front of the class, raise the question as to how seeds germinate, and discuss with pupils the particular methods of experiment that may be used to give accurate information upon the chief points raised. Experiments demonstrating the absorption of water, respiration including generation of heat, as well as the digestion and absorption of reserve food (as in the case of wheat seedings), may be mentioned as being very important.

"Home Work": Systematic Observation of a Plant throughout its complete Life.

A number of annual plants might be carefully selected and seeds (*1d.* packets will serve) of same obtained. Each pupil might be invited to select a packet and to undertake to sow the seeds in a pot of soil, and to personally attend to the wants of the plant until it flowers and sets its seed. A written account of the pupil's observations during the season of growth might be required. Suggestions as to what to look for should be given to the class from time to time.

Spring-flowering Trees.

The study of early flowering trees must not be overlooked. Compare with early flowering bulbs and get pupils to refer to their notes and sketches of testing flower-buds studied in winter. Question as to reason why the flowers can be produced so early in the year, and whether there is any apparent advantage in their appearing while the tree is still leafless.

The class should be taken again out of doors for an excursion in late spring in order to note the outburst of leaf and flower buds and the progress in growth made by twigs and by the shoots arising from the underground structures of herbaceous perennials. Note should also be taken of growth in cultivated plants in field and garden.

Simple Experiments illustrating Phenomena of Plant Growth.

About this period simple experiments, devised for the purpose of illustrating some of the more striking phenomena of plant growth, might be undertaken by the pupils. Measurement of the rate of root and internodal growth; comparison of growth in light and in darkness; "sleep" movements, &c., may be mentioned as suitable experiment for this stage.

Gradual Passage into Summer. Field Work in early Summer.

Summer Studies.

During early summer attention should be directed to the behaviour of plants during growth, the distribution of the root in order to collect water, the placing of the leaf-blade so as to obtain the maximum amount of light, the means of checking loss of water by transpiration, the action of twining stems, and of tendrils, and kindred phenomena. Of course this information to be real can only be obtained by the class from observation in the field or in the garden.

Grand Period of Growth.

At this period of the year the majority of plants are growing fast; it is the season of individual growth and development, and will be immediately succeeded by the grand period of flowering, when the plant's vital efforts will be concentrated upon the production of young.

Reproductive Period of Plant's Activity.

Flowers have been noticed since early spring, and the pupils have been encouraged to note their appearance, but summer is the best time for detailed comparative study of them, and for lessons and exercises dealing with the rudiments of plant classification.

Plants other than Flowering Kinds.

It is suggested that pupils might be made familiar with the broad natural history characters by which the great groups of local vegetation may be recognised in the field—Flowering plants—ferns—club-mosses—"horse-tails"—mosses—liverworts—fungi—algae.

Examination of Flowers.

In the selection of flowers for detailed class-room study, care should be taken to include types of the great sub-divisions of flowering plants. The following list will serve as a guide :—Buttercup—wallflower—pink—flax—pea—rose—wild parsley—dandelion—potato—stinging nettle—pine.

The adaption to secure fertilisation ought to be studied in all cases.

No Teaching of Classification until Pupils have something to classify.

No attempt should be made to teach "classification" until all the above or similar types have been dissected, sketched, and described. When that is done, the class may be told the characters that botanists have selected as indicative of affinity among the series of plants, and the pupils' discrimination tested.

Literature.

The best text-book for teacher and taught is presented by Nature. The teacher will during his own studies meet with various books; but he should secure the most stimulating of all, Oliver's English edition of Kermer's "Natural History of Plants." The best book of reference for the pupil should be that which contains his record of the year's work.

FOURTH YEAR SYLLABUS.

Method of Study.

Small schools taking up the course in Botany may have the fourth year's pupils taught concurrently with the third year's pupils, provided the total number registered does not exceed twelve. Since a large part of the work consists in observations and experiments, and the recording of these by means of sketches and tabulation, one teacher may efficiently supervise the work of twelve pupils working the third and fourth years' courses concurrently.

A short demonstration to one set of pupils can be so arranged as not to interfere with the practical work of the other set.

Pupils of the fourth year will thus have an opportunity of revising the more important parts of the third year's course while they are performing the physiological experiments, many of which will require several weeks for completion. The chief advances made in this course over the third year's work are :—

1. The greater prominence given to experimental work.
2. The frequent use of the microscope.
3. The study of typical orders and practice in the use of Flora.
4. A fuller acquaintance with non-flowering plant associations in the field.

The teaching must be esentially practical. It is particularly desirable that field demonstrations should be given from time to time, and the pupils instructed in methods of observations and note-taking.

Each pupil should be required to record in a book specially kept for the purpose all the experiments and observations made by himself together with the date on which the experiment or observation was made. It is suggested that in all the experimental work some definite method of note-taking be adopted, such as :—

(1.) The problem stated; that is to say the object of the experiment.

(2.) The method adopted to solve the problem.

(3.) The result obtained and the answer it gives to the enquiry.

Sketches should be given whenever possible.

It is recommended that arrangements be made whereby plants may be grown in or round the schoolroom. Windows should be utilised for this purpose.

A number of flower-pots of various sizes, together with potting soil, will be required. Potting soil for general purposes may be made by mixing a fibrous loam (such as may be obtained from a good pasture or hedge-bank) with sand or road sweepings and a little soot.

Good drainage should be provided by placing a number of pot-sherds at bottom of flower-pot, over which may be placed a layer of fibrous material to prevent the soil from choking up the drainage. Attention should be paid to watering.

In the experimental work the pupils themselves should be required to fit up the apparatus, conduct the experiments, and record the results. The teaching should be directive and suggestive rather than demonstrative. The class should be made to feel the necessity for an experiment before it is set to work to perform it; the teacher should receive suggestions and encourage originality.

Teachers will use their own discretion as to the particular order in which the different subjects will be taken in class. It will be wise to look well ahead so as to have specimens available in suitable condition at the proper time.

NOTE.—*The following syllabus consists in the main of a list of experiments indicative of the character and scope of the work. The teacher must supply the logical thread required to connect the various observations and experiments together. The value of the course will entirely depend upon the ability, skill, and enthusiasm of the teacher in making any particular series of experiments and observations appeal to the imagination and intelligence of the pupil, thus enabling him to grasp the thread of the story which it is the object of the experiments to tell.*

Outdoor Studies. In addition to the work particularised below under "Recognition of Plants in the Field," pupils are expected to continue the outdoor studies (adding to the Nature Calendar) begun in their third year.

Seeds and Germination.

1. Study soaked seeds and seedlings (raised in pots of sand) of (*a*) bean, pea, or acorn, (*b*) buckwheat, ash, or wheat, and (*c*) radish, turnip, or mustard

Study of the Early Life of the Plant.

2. Devise experiments to demonstrate power of living seeds to absorb moisture, and to show that dry seeds are able to withstand extremes of temperature better than moist ones. Will seeds killed by drying absorb water as readily as living ones ?

3. Demonstrate as to influence of temperature upon germination.

4. Show by actual experiment—(1) that germinating seeds absorb oxygen and generate carbonic acid gas, and (2) that heat is liberated during this respiratory process.

5. Study the character of the food supply stored in the endosperm of wheat grains by making a mechanical analysis of wheaten flour, and testing the discovered albumen and starch. Demonstrate the presence of mineral matter (the ash) in a wheat grain.

6. At this stage let pupils cut thin sections from a potato tuber, or from the scale leaf of a lily bulb, and examine and sketch cells and their contents as seen under the microscope. Compare these with similar sections cut from a wheat grain.

7. Study sprouted wheat grains, and note especially the progress in growth made by the embryo and the difference in character of the floury contents of the grain. Test the milky substance for sugar. Examine the partially digested material under the microscope, and note the altered appearance of the starch grains.

Growth of the Seedling.

1. A variety of different seedlings should be studied. Observe in the case of maize, beans, buckwheat, &c., the gradual digestion, and subsequent transference, of reserve food to the seats of growth and recapitulate necessity for warmth, moisture, and respirable air.

2. Study a complete seedling of pea or bean (and sketch to scale) with soil particles attached to root. Note the difference in appearance between the growing points of the stem and the root.

3. Discover by experiment the elongating regions of root and shoot.

4. Selecting seedlings of such suitable plants as nettle, poppy, turnip, etc., examine the root system, first under a lens, and then the growing point and root-hair region under the low power of the microscope.

Observe the growing points of the young root-branches breaking through the cortex of the main root.

5. Conduct experiments to demonstrate irritability of root tips to (*a*) gravity, (*b*) contact, (*c*) light, (*d*) moisture.

6. Watch as closely as possible the development of the foliage

leaves and the gradual elongation of internodes in growing seedlings kept under healthy conditions.

7. Keep seedlings of buckwheat or mustard, some growing under normal conditions, and others in poor light, or complete darkness, and watch the gradual starvation of seedlings in the latter case.

The Plant Itself.

1. Selecting one or two types, carefully study in each the origin, arrangement, and form of the various organs concerned in the nutrition and development of the individual.

Period of Vegetative Development.

2. Examine leaf-buds, make out their structure, and follow their development into shoots. Study the formation of the root-system.

3. In a variety of selected plants make out the character and arrangement of the skeletal tissue, that is, the tissues that give mechanical support to the different organs.

4. Study, with the aid of pocket lens, the vascular system of some easily dissected stem, such as vegetable marrow or potato. Show the tubular structure of woody tissue by examination under a microscope. Sketch sieve-tubes as seen under the microscope.

5. Inject leafy shoot of potato with eosin, and trace ramifications of bundles in stem and foliage

6. Discover position of cambium in woody stems of different ages, and understand its function.

7. Arrange a series of experiments to illustrate the irritability of plants. In cases of movement of position, differentiate between the sensitive and motor region. "Sleep" movements and movements stimulated by contact are to be specially studied. Hygroscopic movements in relation to seed dispersal and seed-burying should also have attention.

How the Plant Lives.

Respiration—

1. Show by actual experiment with germinating seeds, bulbs, tubers, etc., and with opening flowers—(1) that living plants spontaneously oxidise, that is, they use up oxygen and give off carbonic acid gas, and (2) that heat is liberated during the process.

2. Importance of respiration to living beings.

3. Demonstrate presence of air in different organs of plants by immersing detached parts in hot water, and watching the escape of the expanding air. Discover presence of lenticles in twigs, and find, with help of a microscope, stomatal openings in the epidermis of leaves.

The Plant in Relation to the Soil—

1. Make a mechanical analysis of ordinary garden soil.

2. Ascertain percentage of organic matter present.

3. Take a very small quantity of the finer earth, spread it out on a glass slip and examine under a miscroscope. Now dry

the soil on the slip and again examine. Note the difference in appearance.

4. Examine under the microscope a living root-hair with soil particles attached. Seedlings raised in a pot of fine sand supply good material.

5. Devise experiments to show osmosis in a cell or a tissue—such as placing a rigid succulent tissue in a salt or sugar solution, and when limp restore rigidity by soaking in fresh water.

6. Set up a series of water—and pure sand—culture experiments in order to demonstrate the need of nitrates and certain minerals to growing plants.

7. Grow peas or other leguminous plants, raised in damp sawdust, in (1) pots of ordinary garden soil, (2) ordinary garden soil sterilised.

Note presence of root nodules in the one case and their absence in the other. Meaning and use of these root nodules.

Movement of Water in Plants—

1. Arrange experiments to demonstrate (1) root pressure, and (2) the lifting power of transpiration.

2. Selecting a suitable plant freshly removed from the soil, cut through the lower part of the main root and inject with eosin. Dissect the plant in order to follow the ramifications of the injected tissues and thus discover the position and character of the channels through which water is conducted from root to foliage.

3. Prove that water (in the form of vapour) escapes from leaves under ordinary conditions.

4. Examine fragments of leaf epidermis under the microscope and observe stomata.

5. Take a plant or part of a plant and discover the exact amount (both by weight and volume) of water lost in a definite time, being careful to note the existing external conditions that influence the loss of water in this way.

6. Ascertain by experiment if one side of a leaf loses more water by transpiration than the other.

7. Discover, by actual experiment, the atmospheric conditions that most influence the rapidity of transpiration.

8. Importance of transpiration to a growing plant.

Carbon Assimilation—

1. Preliminary experiments with leaves to demonstrate presence or absence of starch. (Sachs' iodine method.) Ascertain if the white or non-green areas in variegated leaves shows presence of starch.

2. Test for presence of starch (1) in leaf taken from a plant exposed all the morning to bright sunlight, and (2) in a leaf taken from same plant after being kept in darkness for twelve hours or so.

3. Devise a simple experiment with submerged water plants to prove that when a green plant is exposed to sunlight, and kept at a proper temperature, and in presence of carbonic acid gas dissolved in the water, oxygen gas will be liberated, and starch will make its appearance in the leaves.

4. Show that the evolution of oxygen ceases if the plant is (1) shaded, (2) chilled, or (3) kept without carbonic acid gas. Discover if oxygen is evolved under the influence of (*a*) blue light, (*b*) red light.

5. Grow a pot-plant under a glass bell-jar, taking care that all proper conditions of growth are secured, with one exception, namely, the absence of carbonic acid gas in the air within the bell-jar. Test the leaves for starch after exposure to strong sunlight for some hours.

6. Using a variegated leaf, ascertain if starch is formed in absence of chlorophyll.

7. Make out, under the microscope, the chief tissues of the leaf (1) the epidermis, (2) the soft, green, cellular tissue, and (3 the veins, and note especially the presence of chlorophyll bodies within the cells. Extract the chlorophyll from the leaf cells by means of alcohol.

8. Study the air chambers in the leaf.

Storing Reserve Food—

1. Examine unripe grains of corn, and taste the sweet contents. Compare with ripe grains and note differences.

2. Examine tubers, &c., for starch or inulin; carrot, or other roots, for sugar; and turnips, &c., for solid albuminoids; seeds for oil and granular albuminoids.

The Flower, the Seed, and the Fruit.

1. Conditions favouring the formation of flowers.

2. The parts of a flower. Examination of types. Construction of floral diagrams.

Period of Reproductive activity.

3. Detailed study of stamens and pistils, including a microscopical examination of pollen, and of artificially germinated pollen grains; of stigmas showing attached pollen grains (flowers of chickweed will serve), and sections of ovules, showing the egg cell.

4. Methods of pollination, natural and artificial; study of floral form and symmetry in relation to insects.

5. Ascertain by actual trial if fertility depends upon cross-pollination in particular flowers; discover cases where self-pollination is the rule.

6. How embryos are formed. Ripening of seeds and fruits. Study of fruits and dispersal of seeds.

Recognition of Plants in the Field.

During excursions the pupils of the fourth year should be introduced to the use of a school Flora, but at first under the guidance of the teacher, because of the large number of technical terms that seem to be inseparable from such books.

The Orders to which the list of plants given in the third year's course belong, are to be studied; and it is expected that the pupils will be able to recognise by reference to a Flora the native *generae* and species of these orders. No independent knowledge, however, of *genera* and species will be expected. In all cases, attention ought to be paid to *habitat*.

A lesson illustrated with exhibits of varieties, hybrids and double flowers will not be out of place, especially with regard to the interest of the pupil in garden flowers.

A general acquaintance with such groups of non-flowering plants as form well-marked associations likely to be met with in the field will be expected. Ferns, mosses, liverworts, mushrooms and other fungi, including lichens, seaweeds, freshwater *algae*. It is not necessary that the names of any members of these groups should be known, but that pupils, for example, should be able to recognise as a moss any member of the moss family. The particular *habitat* ot the plants ought to be noted in each case.

Homework.

In the third year it was suggested that pupils should keep a potted bulb under observation at home, and watch and record its growth and development during the season. Fourth year pupils might be given a somewhat similar task, only the selection of a subject might well be left to the individual fancy of the pupil. A tree is an excellent subject.

(7.)—PHYSIOLOGY AND HYGIENE.

NOTE.—This syllabus contains subject-matter for a two-year course of study in Day Secondary Schools, as follows :—

First-year Course.—Physiology, I., II., 1, 2, 3, 4.
Applied Physiology, Hygiene, I., II.
Second-year Course.—Physiology, II., 5, 6, 7, 8, 9.
Applied Physiology, Hygiene, III., IV.

The pupils of the second year are also expected to have a competent knowledge of the matter of the preceding sections.

INTRODUCTORY.

Remarks suggested by the structure of the human skeleton form an appropriate introduction to the study of Physiology. Note the division into the skeleton of the trunk and that of the limbs. The vertebral column, a canal continued into the cavity of the skull, serves for the protection of the nervous system which it encloses. It is also an axis for the general support of the trunk. Through the holes placed between the vertebræ the nerves pass out to the body to transmit the messages which put the central nervous system into communication with all the other organs. Strength and solidity in the supporting column are obtained by its fixation to the pelvis; adaptability to movement by the general plan of articulation. The light cage formed by ribs and cartilages assists in the formation of the trunk and serves to protect the heart and lungs. Next point out the plan of structure common to all the limbs, What advantages result from the loose attachment of the upper limbs? Why is the pelvic basin so strong, so firmly united? Then the smooth articular surfaces of the limb bones may be shown, and the range of motion possible in the several joints illustrated from the shape of the joint cavities. The pupil is now asked to consider how locomotion is effected. The muscles, as straps of contractile flesh passing from bone to bone, provide the immediate mechanism; but what excites them to act? The motor nerves come *from* the central system. Quite a different function is that by which the skin sends impulses *to* the central system. Finally, the nourishment and sustainment of the whole body is provided for by digestive and other organs placed in the cavities of the trunk; and by the vessels, which penetrate all parts, the heart sends the blood through all. The names of the bones of the limbs, the classification of the teeth, deformities, such as spinal curvature and misshapen chest, and a variety of general information can be dealt with in the lessons given on the skeleton.

PHYSIOLOGY.

I. ANATOMICAL STRUCTURE.

Kill a rabbit with chloroform. The brain should be removed at once and placed in strong spirit.

Dissection of a Rabbit.

To remove the brain: dissect away the skin of the head and then expose the brain by snipping away, with a bone forceps, the roof and sides of the skull, beginning at the foramen magnum and working forwards. Cut through the dura mater which lines the cranial cavity. Cut across the spinal cord half an inch behind the foramen magnum, and turn out the brain carefully from behind forwards with the handle of the scalpel. Identify the several nerve roots; cut through them in order. Leave the brain in the preservative for a few days and then dissect and examine the parts carefully.

Lay the animal on its back, and fasten it down to the dissecting board by pins through the limbs. Make an incision in the ventral surface of the body from the anterior end of the breast bone to the pubis. Make transverse incisions at both ends of the median one and reflect the skin on both sides fully. Open the abdomen by a deep cut in the middle line from the end of the breast bone backwards. Cut outwards for about two inches on each side behind the ribs and pin out the flaps right and left. You now see the following viscera:—Liver, stomach, small intestine, and part of the large intestine. Turn the alimentary canal over to right side and expose the spleen, kidneys, adrenal bodies, diaphragm, mesentery, and vermiform appendix. The pancreas with its duct, lies in the duodenal loop. Now note the bladder behind the pubis. Examine the bile duct which passes from the liver to the duodenum, and then follow up the portal vein to its entrance into the liver.

Carefully cut through the mesentery with scissors along the whole length of its attachment to the intestines, except at the duodenal loop. Lay out the gut on the dissecting hoard, and identify in order stomach, duodenum, jejunum, ileum, cæcum, colon, and rectum. The internal structure of the parts may be studied by slitting up portions of them and examining under water.

Now remove the alimentary canal, by cutting through the œsophageal end of stomach and through the rectum near pelvis, and also the liver. Trace out course of bile duct from gall bladder and liver to the duodenum. What are the lacteals? What is the lymphatic system?

Open the thorax by a transverse incision just in front of diaphgram; cut through the ribs along each side, and remove the ventral wall of thorax as a triangular piece, taking care not to injure the vessels and other structures beneath it. Identify and examine the following parts *in situ*:—thymus, heart enclosed in pericardium, lungs, diaphragm, pleura, œsophagus. Remove the thymus and carefully clean the base of the heart and the roots of the great vessels. Identify the several parts of the heart, and trace the great vessels so as to show their branches or tributaries, and course. Point out the terminations of the venus system in the auricles, the origin of the arteries in the ventricles of the heart. Follow the trachea and œsophagus through the neck. Show the termination of the trachea in the larynx, of the œsophagus in the pharynx.

The thyroid gland may be seen on the sides of the trachea. The submaxillary (salivary) gland will then be found near the lower jaw.

The brachial plexus of nerves are next investigated as they enter the tissues of the fore limb in the axilla. The muscles of the fore limb are to be exposed by dissecting off the skin, and the mode of origin and insertion of one or two muscles may be demonstrated.

The kidneys still remain on the posterior abdominal wall, and may now be studied.

The rabbit is now to be turned over on its ventral surface, the skin removed over the dorsal and lumbar region, a deep cut made into the muscles of the latter region on each side of the vertebral column, the flesh cut away, and the vertebral arches carefully snipped and removed to expose the spinal cord.

The course of the principal arteries, carotid, temporal, subclavian, axillary, brachial, radial, palmar, femoral, should be pointed out on the chart of the human body. A knowledge of their positions is essential when one has to stop hæmorrhage in an emergency.

II. PHYSIOLOGICAL FUNCTIONS.

The activities or functions carried on by the living body are described under the following headings :—(*a*) Digestion, (*b*) Circulation, (*c*) the Blood, (*d*) Respiration, (*e*) Excretion, (*f*) Temperature, (*g*) Movement, (*h*) Nervous System, (*i*) Vision and other sensations.

1. Digestion.

The study of digestion should be preceded by a description of the chemical constituents of the animal body. The principal organic compounds of plants and animals are proteids, carbohydrates and fats. Show that proteids contain nitrogen, as well as carbon, hydrogen, and oxygen ; that they are absolutely essential for the formation of living matter, because found in every cell, while carbohydrates and fat, without nitrogen, are of secondary value to proteid. A brief lesson on the composition of animal and vegetable tissues will enable the pupil to appreciate the principal facts of physiological chemistry, and grasp the reasons for the selection of our ordinary food stuffs. This introduction may be accompanied by practical demonstration, somewhat as follows :—

Proteid.—Presence of nitrogen shown by heating dried white of egg with soda-lime. Presence of carbon by charring.

Take white of egg, chop with scissors, dilute with ten volumes of water, and beat it up well to make it fluid ; filter. To the filtrate apply the following tests :—

1. To a small quantity add a few drops of strong nitric acid ; precipitate forms. On boiling, it turns yellow ; add ammonia carefully till it becomes orange (xanthoproteic test).

2. To a small quantity of the solution add an equal volume of a strong potash solution and then one drop of sulphate of copper, one per cent. strength. The fluid becomes violet (biuret test). Perform a control test on water and compare result.

3. Add a few drops of Millon's re-agent (impure nitrate of mercury) ; precipitate forms turning red on boiling. Other reactions may be shown by coagulation with heat and by precipitation by corrosive sublimate.

Varieties of Proteid.—The chief proteid in white of egg is egg albumin. A somewhat similar proteid, serum albumin, is found in the plasma of blood. The presence of this albumin and of another proteid (globulin) may be demonstrated in serum of ox blood (obtained from a butcher).

Method.—First demonstrate the colour reactions given above on a portion of this blood serum. Separate the two proteids in another portion by saturating the fluid with magnesium sulphate ; precipitate of globulin forms. Filter to remove it, redissolve it in water to which a little of the salt is added, try colour reactions on this solution, and note results. Heat the filtrate and note results. The albumin, which was not thrown down by the salt, coagulates. The presence of similar proteids in bread may be demonstrated by extracting wheaten flour with

10 per cent. sodium chloride for some hours. Apply same methods and note results. Similar experiments may be performed on the meal of maize and pea. Milk may now be investigated. The whey of milk responds to the colour reactions showing the presence of milk albumin. The principal proteid of milk, caseinogen, is present in large quantities in uncurdled milk. To the latter add acetic acid, and warm, or saturate with magnesium sulphate and shake vigorously, a precipitate of caseinogen (and fat) falls, leaving whey. The composition of lean meat or muscle may then be examined.

Can a proteid in solution pass through an animal membrane? Test this, using a piece of dried gut of a young animal (pig). Diffusible and indiffusible substances can now be described. What is a peptone?

Carbohydrates.—Why so called? Demonstrate absence of nitrogen. They are charred by heat, carbon is present.

The chief examples are starch, grape-sugar or dextrose, maltose or malt-sugar, milk-sugar, and cane-sugar. Compare the solubilities of these substances in water. Next investigate their response to the application of a weak solution of iodine. Then try the reducing reaction with copper salts in the following manner:—Dissolve some grape-sugar in water. Take a little of the solution in a test tube, add an equal quantity of strong potash and one drop of sulphate of copper solution of one per cent. strength. Boil. What is the yellowish red precipitate which is formed? (Refer to the application of the same reagents in a different reaction for proteids.) Next show how starch, or cane-sugar, not giving the reducing reaction, may be turned into a reducing sugar by boiling for some minutes with a little strong hydrochloric acid. Next try if the starch will pass through an animal membrane, repeating the experiment as performed for proteid. Is grape-sugar diffusible? The presence of starch in potato, wheaten flour, and other food stuffs may be easily demonstrated by means of the iodine reaction.

Demonstrate the action of yeast on grape-sugar and refer to the use of yeast in the formation of alcohol and in the baking of bread.

Fats.—What do they contain? How does paraffin oil differ from such an oil as olive oil? Take olive oil and lard, try their solubility in water, ether, chloroform, boiling alcohol. Next show the formation of an emulsion by adding a little potash to water mixed with the oil. What is an emulsion? Look at it under the microscope with a high power. Examine milk with the same magnification. The fat of milk may be separated by shaking a mixture of milk, ether, and some strong solution of soda in a stoppered bottle. The etherial solution comes to the top and it may be removed. The ether is allowed to evaporate and the fat remains.

Gelatine.—Gelatine is nearly related to proteid. It exists as collagen in fibrous connective tissue and in the animal matter of bone. The composition of bone may be shown by placing a piece of the fresh bone of a rabbit in weak hydrochloric acid for a couple of weeks until it is soft enough to be penetrated by a pin without resistance. The calcareous matter is thus removed. The soft bone (animal matter mainly collagen) is now subjected to prolonged boiling, and jelly or gelatine is formed. It is recognised by its jelly-like state in the cold. Is gelatine able to replace proteid in the dietary?

2. The work of Digestion.

What is the object of digestion? To make proteid, carbohydrate, and fat capable of absorption through the lining membrane of the intestine into the blood vessels which run in its wall. Mention the agents, enzymes, by which this is accomplished, the fluids in which they are contained, and the glands connected with the alimentary canal by which they are formed. Describe the results of their action on the food stuffs, and demonstrate as follows:—

For Carbohydrate.

Saliva (*Ptyalin*).

(1) Boil starch with water; when cool add saliva, and keep at a temperature of 100 degrees F. some minutes. Now test for the presence of a reducing sugar.

Pancreatic Juice. (*Amylopsin*).

(2) Perform a similar experiment with a preparation of pancreas extract obtained from the chemist.

(*Diastase*).

(3) Another experiment with the vegetable enzyme contained in malt extract. What use do plants make of this ferment? What is the first stage of brewing?

For Proteids. Gastric Juice.

(*Pepsin*).

(4) Mix solution of white of egg with one half per cent. hydrochloric acid, add glycerine extract of the stomach, which contains pepsin. Keep at a temperature of 100 degrees F. for a few hours on a water bath.

Note results by the following tests:—

Pancreatic Juice. (*Trypsin*).

(*a*) Does it coagulate on heating?

(*b*) Why does it give a pink colour with potash and copper sulphate, not a violet?

(*c*) Test its diffusibility through a piece of dried gut.

(5) Make a similar experiment with white of egg solution dissolved in 1 per cent. sodium carbonate solution, to which you have added extract of pancreas, and note results as before. Why must the former solution (4) be acid, the pancreatic solution alkaline? Next keep the digestive mixtures (4) and (5) for a day or two. Why does putrefaction occur in (5), not in (4)?

(6) Peptonize milk with pancreas extract.

(7) Demonstrate curdling of milk by the addition of rennet extract, placing on the water bath at a temperature of 100 degrees F. for some minutes. What is cheese?

A control series of experiments may be carried out in each of the above cases by boiling the fluid immediately after the addition of the solution containing the enzyme. This type of experiment may be applied to other kinds of food stuff, such as hard-boiled white of egg, bread, fibrin, gelatine, small pieces of muscle, and the formation of the diffusible products demonstrated.

For Fats.
Pancreatic Juice.

Fat splitting action of enzyme in pancreatic juice. Formation of emulsion with pancreas extract and sodium carbonate.

Bile.

The action of bile as a feeble emulsifier of fats may be shown.

Intestinal Juice.
For cane-sugar.

Illustrate its action on cane-sugar by the similar action of hydrochloric acid and boiling.

The general description of digestion may then be given, supplemented by special reference to the teeth, the peristaltic movements of the canal, the use of the lacteals and the portal vein for absorption of food stuffs, and lastly, intestinal putrefaction.

3. Circulation.

The dissection of the heart and blood vessels will have suggested the chief questions of interest, and provided an opportunity for an explanation the general principles of the circulation. Practical work may be outlined as follows :—Show the automatic action of the heart in a frog which has been killed and pithed. Show the blood stream in a living frog by spreading out the web of the foot under the microscope, and examining with a high power. The presence of pulsation in the arteries and its absence from the veins may be seen by reference to the vessels of one's own fore arm. Attention should be specially directed to the capillaries and to the mode by which fluid transudes through their walls into the surrounding tissues. Pressure, velocity, and the general difference in structure and function between arteries and veins may then be described. Manometer or pressure gauge, shown by a U-shaped tube containing mercury, and the mode of demonstrating blood pressure illustrated. The pressure is great enough to carry on the flow even against gravity. But if the heart is feeble or the system lowered, gravity may be sometimes a useful help. Hence a fainting person should be laid on his back.

The nervous control of the blood vessels may be explained in connection with the occurrence of blushing.

Blood.—The general description will include an account of the cells and the fluid or plasma, their composition and functions. Practical work. Examine a drop of blood under the microscope with a high magnification. Note the form of the cells, their colour in thin layers, and where massed together. Compare a drop of frog's blood. Note the difference in the shape and structure of the red cells. The white cells are more easily seen here. Receive a little blood from the heart of a rabbit, just killed, into a small beaker, stirring the blood with a bottle brush as it flows. This leaves the blood fluid while rapidly removing the fibrin. Shake up some of the blood in a test tube; note its scarlet colour due to the colouring matter, hæmoglobin. It is now chemically united with the oxygen absorbed from the air. Add a few drops of ammonium sulphide and warm gently; what change of colour occurs, and why? Arterial and venous blood can now be referred to, and the function of the red corpuscles as oxygen carriers from the lungs to the tissues described. (3) Receive some fresh blood from the heart of a rabbit, just killed, into a solution of potassium oxalate, half per cent. strength; the oxalate prevents coagulation. Why? Receive another portion into an empty test tube, it clots immediately, at first becoming a jelly. Lay it aside for twenty-four hours, and now note the soft red clot floating in a clear fluid, the blood serum. Experiments may be made on the oxalated blood to show how the presence of lime salts is essential for clotting of the blood. What is fibrin? How does clotting help to stop bleeding?

Carbon monoxide poisoning.—Take a test tube, half fill with defibrinated blood, connect an india-rubber tube with the gas pipe and put the free end of the tube into the blood in the test tube. Turn on the gas until it saturates the blood. What change in colour occurs? Why? Then refer fully to the danger of poisoning by carbon monoxide. How is the carbonic acid gas of expired air held in the blood?

The description of the phenomena of the circulation should be followed by a brief reference to the lymphatic system.

4. Respiration.

Kill a rabbit with chloroform. Carefully dissect the wind-pipe in the neck, ligature it so as to effectively close the tube. Now by careful dissection down to the ribs and breast-bone, and then by opening the chest cavity show that the lungs distended come close up to the chest wall. In a second rabbit show that if the chest is open without the precaution of ligaturing the wind-pipe the lungs collapse on penetrating the thoracic cavity. Remove the lungs and wind-pipe in one piece in the case of the second rabbit, and show by injection of air into the wind-pipe that the lungs can be very much distended. Show that when collapsed they still float in water. Now refer the pupils to the walls of the chest cavity, forming a cage of light ribs and cartilage, with muscles intervening and floored by the muscular diaphragm. Describe the pleura, and by reference to the experiments performed, show how the lungs are always in a state of distension during life, increasing with the active increase of the chest cavity during inspiration, diminishing with expiration. The lungs are therefore passively made to follow the movements of the chest walls as long as the pleura are intact. What excites the muscles of respiration to act? Where is the nervous centre which controls them? How many times per minute do respirations occur in man? The chemistry of respiration is then considered, the composition of air, the outgoing air, the amount of tidal air of ordinary respiration, the capacity of the chest, and the degree to which the air of expiration modifies the composition of the air of the room in which one lives are fully explained. The properties of hæmoglobin as an oxygen carrier may be described, and the affinity of the hæmoglobin for the poisonous carbon monoxide may again be demonstrated. Where does the oxygen go to? Where does the carbon dioxide come from? Is the oxygen held in the blood like air in soda water?

5. Excretion. In the dissection of the kidneys the arrangement of the blood vessels and duct (ureter) may be investigated. The minute structure in branched tubules, and the disposition of the blood vessels to promote filtration through one portion of the tube, and the more special selection of chemical substances can be described. What happens after removal of both kidneys from a living animal? Name the principal ingredients removed from the body by the kidneys.

The sweat glands, sebaceous glands, and hair will be described in connection with the several functions they discharge. How much water is removed from the body by the skin, the lungs, the kidneys, in 24 hours? How is heat lost through the skin? How far does suitable clothing regulate its loss?

6. Temperature. Where is heat produced in the body? How is it removed from the body? How is the temperature kept constant in man? What is the meaning of fever? What is the value of the several fabrics used for clothing as heat conductors? How is the temperature of the body taken with the clinical thermometer? What is it in the axilla? In the mouth? What is the value of woollen clothing as an absorbent of perspiration? What is the danger from cotton and linen in profuse perspiration?

7. Exercise. The growth and increased facility of muscles for their proper movements may be taken as the explanation of the value of training in athletics, and the usefulness of habitual exercise. As one learns to write by practice, so by regular exercise all movements are accomplished with more facility. Need of exercise for the muscles of the back in young children to prevent spinal curvature; freedom from constriction of the chest requisite for normal respiration.

Show that the three orders of levers are exemplified in the actions of muscles, flexor of forearm (biceps) 3rd order, extensor of forearm (triceps) 1st order, standing on tiptoe (calf muscles) 2nd order.

8. Nervous System.

Illustrate the general principles by a series, such as the following:—Voluntary movement, tactile sensation, reflex from the sole of the foot, and automatic control of movements of respiration.

9. Vision.

A rectangular box without a lid, into one end of which is fitted a lens like a watch glass, is a useful piece of apparatus for demonstration. Place within the box a moveable bi-convex lens and a piece of flat dull glass to represent the retina. Fill the box with water and show the formation of images of a gas flame. What is the pupil? The cornea? The lens? The retina?

APPLIED PHYSIOLOGY, HYGIENE.

I.—MAINTENANCE OF HEALTH

IN RELATION TO WATER, AIR, FOOD, INFECTION AND ALCOHOL.

Water.

Water as a solvent. The rain falling on the soil and percolating through it will receive a great many substances into solution before it re-appears in springs, wells, rivers, &c. Drinking water contains traces of many such substances, ordinarily not in quantities injurious to health. Name them. Hardness, a very simple deviation from the average by presence of too much lime salts. What salts may be injurious if conveyed through leaden pipes? Great dangers—that of organic impurities from decomposing animal matter, and infection. How far are we helped in the recognition of such materials by taste, colour, odour, sediment? Show that these properties may have no necessary relation to the presence of dangerous organic impurity in water. Where ordinary filters fail to remove infective microbes, boiling, a simple but effective means of doing so. Practical work should proceed as follows:—

Chemical Substances in Solution.—(1) Show the presence of chlorine in ordinary drinking water by means of silver nitrate. (2) Make up Nessler's re-agent, namely—solution of mercuric iodide in potassium iodide with the addition of an alkali. Demonstrate its value in detecting ammonia. What does a marked ammonia reaction in natural water indicate? (3) Hardness, temporary and permanent. Add 10 grammes of Castile Soap to one litre of dilute alcohol (35 per cent.). Take 100 cubic centimetres of water, add a few c.c. of the soap solution. Note precipitate. Then shake, and study formation of a lather. To distinguish permanent from temporary hardness, measure 250 c.c. of water; boil for half an hour; when cool pour off supernatant fluid so as not to disturb sediment, and treat the filtrate with the soap solution (one c.c. soap solution is equal to one milligramme carbonate).

Sediment.—Describe the different kinds of filter and construct a simple filter with a clean flower pot and gravel, sand, &c. What is a Chamberland filter?

Examine the sediment of pond water under the microscope. Note the presence of various animal and vegetable forms.

Demonstrate the use of Condy's Fluid. Explain its action. The subject matter of water contamination explained, the attention of the pupil is directed to the supervision which must be exercised in relation to the selection of a source of supply: its protection from contamination; distribution, storage; quantity of water per head for daily use; and the final disposal of waste water.

Air.

The composition of air, and the modifications due to animal respiration have been already given. Other conditions modifying the atmosphere are suggested by cloud, smoke, dust, and the various impurities arising from the surface of the earth. The general principles of its purification—diffusion, winds, rain, and sunlight—naturally follow. The value of oxygen, essential to life, is next referred to. Under ordinary circumstances danger does not arise from want of this gas, but from the accumulation of impurities in enclosed places.

The chief impurities are:—

Chemical.—(1) The air of expiration, carbonic acid gas; (2) carbonic acid gas from other sources, such as pits, deep wells, brewery vats, sewers; (3) from carbon monoxide, escaping by leakages from gas pipes, or accumulating from imperfect combustion.

Mechanical.—(4) Minute solid particles, wood, coal, or metal in the air of factories.

Infective.—(5) Disease-producing microbes arising from centres of infection.

The air of respiration becomes unwholesome when the carbonic acid gas accumulates to about twice the normal amount contained in the air. Show that this, in rooms, necessitates a space of 1,000 cubic feet per head with ordinary ventilation. Demonstrate the presence of carbonic acid gas in the air of expiration by means of lime water. Next employ a 10½ ounce bottle, containing half an ounce of lime water, to determine if the air in a room has more than its normal amount of carbonic acid gas. Show the poisonous action of carbon monoxide by experiment referred to in the section dealing with blood.

Ventilation.—Simple experiments showing diffusion of gases; illustrate one mode of purification. The influence of heat causing air to expand and become lighter is also easily shown. Winds are large movements of the air determined in the same way. This leads to the use of the chimney as the natural ventilating shaft in the room, the window the natural inlet. What is the best mode of ventilation by the window, by lowering or by raising it?

Special modes of assisting ventilation are best illustrated by models of Tobin's tube, Sheringham valve, a louvre, a cowl and Hinckes Bird's block. For very large buildings—artificial ventilation.

Food.

The essential ingredients of food stuffs are proteids, carbohydrates, fats, salts, and water. Dietary includes, besides these indispensable nutritive materials, various accessories, such as condiment, and stimulating beverages, as tea, coffee, cocoa. Food stuffs are only rarely consumed in their natural condition. When cooked the danger of infection is mostly taken away, and food stuff made much more palatable. The true indication of the amount and quality of food we require is found in the amount of carbon and nitrogen removed from the body as waste. The carbon is to the nitrogen as 15 to 1. In proteid the carbon to the nitrogen is 3¼ to 1. The difference in carbon is made up for by taking carbohydrates and fat which contain no nitrogen. Animal food stuffs contain proteid and fat, vegetable stuffs mainly proteid and carbohydrate; hence the mixed diet. What is the average proportion of these in a physiological diet? Give a mere subsistence diet; a diet for very hard manual labour? Economy is attained by the selection of food stuffs which contain large quantities of these three ingredients. Is the diet of an agricultural labourer, if mainly derived from potatoes, economical? How would it compare with a diet mainly consisting of oatmeal? Show the value of the principal food stuffs, animal and vegetable, by a table giving their percentage value in proteids, carbohydrates, and fats. Practical work on food stuffs should be directed chiefly to the recognition of the ordinary appearances which indicate that food is wholesome. (1) Meat—its touch, consistence, colour, smell, distribution of muscle fibre, of connective fibre and fat in a piece of good beef or mutton. (2) Egg—the weight of an average hen egg; determine if fresh or stale by dissolving in a pint of water two ounces of salt and testing if the egg floats in the solution. (3) Milk—its colour, taste, amount of cream outstanding, amount of sediment, specific gravity, microscopic appearance. (4) Fish—its odour and colour. Does fish require to be heated as much as meat in cooking? (5) Wheaten flour—knead in muslin bag under water; show the presence of gluten. What is this substance? What is its value in baking? How is baker's bread made with yeast; with baking powder? (6) Butter—What is margarine? (7) Tinned foods—How prepared? (8) The dietetic value of green vegetables, of fruit. (9) The making of preserves. (10) The use of rennet in the production of cheese.

Beverages.—What is soda water? Why does it effervesce when the cork is removed? Tea, coffee, cocoa. Their active principles, their stimulating action. Presence of tannin in tea. The food value of cocoa. What is chocolate? What is an infusion? What is a decoction? Overdrawn tea, excessive consumption of tea.

Cooking.—A general account of the methods.

Adulteration.—Milk taken as an example, and discussed fully.

Disease-producing food to be suggested by putrid meat, shell fish from stagnant water, worm infected pork, and, most insidious of all, microbe-infected milk.

Infection.

What are microbes? What is their natural home? What are the natural agencies by which they are destroyed? Why is the air of the sea and mountains so pure? Show that some microbes are not disease-producing, though active chemically; instance the souring of milk. Show that jelly exposed to the air for some time becomes covered with microbic growths.

The action of antiseptics, boracic acid, carbolic acid, formalin, corrosive sublimate, may then be referred to. Now enumerate the diseases caused by microbes, and show that milk, water, air, earth, are ordinary vehicles by which they enter the body; that the ejecta, sputum, clothing of infective patients are common modes of transmission. General methods of dealing with microbic infection—(1) prophylaxis or preventive treatment *e.g.*, vaccination; (2) isolation of patients; (3) use of antiseptics, of modes of sterilisation. Among antiseptics, boracic acid suitable for popular use in wounds, injuries, &c.; carbolic acid and corrosive sublimate powerful but requiring caution, as they are strong poisons. Boiling to sterilise utensils, steam for clothing. What kinds of disinfection are best for rooms, sputa, ejecta. Deodorisers, *e.g.*, quick lime, for removing the smell of putrefactive material. Do they sterilise?

Alcohol.

The common use of alcohol necessitates special consideration rather than inclusion as an item among the beverages classified under the heading, food. That it is an intoxicant is a clear indication of its poisonous properties. That it is of some value as a condiment, taken in small quantities with meals, when digestion is feeble, many medical authorities admit. It has also considerable value in phases of disease, but a doctor is the only person competent to determine such conditions. That, as used by the great majority of even sober people, its influence is rather in the direction of harm than of health, is generally true.

What is its composition? Why is it inflammable? How is it made? Its consumption is brought within the limits of safety only by large dilution with water. Strong spirits, such as whiskey, should be diluted with at least six times its bulk of water. Alcoholic drinks, if taken at all, should be consumed only at meals, and then with caution. Alcohol contra-indicated when active exercise is being taken; dangerous if one has to endure prolonged exposure to cold. Alcohol is most injurius to growing children. Classify alcoholic drinks, *i.e.*, beer, wine, spirits. Give a table showing their percentage composition. General rule—the more largely diluted, the safer. Show that alcohol precipitates white of egg from solution, and mention the diseases caused by its use in excess.

II.—PERSONAL HYGIENE.

The Teeth.—The necessity of taking as much care of the teeth as of the hair. The injury to teeth in children from excessive use of sweets, unripe fruit, &c. Need of yearly examination by the dentist.

Alimentary Canal.—Constipation; its common causes, want of sufficient fluid in diet, want of exercise and air. Habitual constipation in young girls producing anæmia, &c.

Respiration.—Avoid tight clothing, such as tight lacing. Remember the air passage begins at the nose, not the mouth, and that respiration should be carried on through the nose. Active exercise needs full and free respiratory movements, and should be carried on in the open air or in a well ventilated place.

Exercise, Rest, and Sleep.—Apply the physiological principle that the nutrition and growth of muscle are promoted by their activity, diminished by want of exercise. Too much exertion determines fatigue, and the muscles and other tissues require rest for their restoration. Sleep—the natural rest for all the organs. For the child, for the hard-working, sufficient sleep a prime necessity. Ventilate the bedroom. In active exercise the heart's action greatly increased. Avoid strain. Out of breath an indication for cessation of active exercise.

Habit.—Regularity in meals and in sleep. Daily evacuation of the alimentary canal. Children warned against the danger of cuts and open wounds in dirty hands. Cigarette smoking in the young a dangerous habit—injurious to throat and lungs. Inhalation of tobacco smoke pernicious. A good habit—modify the dietary occasionally.

Cleanliness.—The skin; an active excretory organ requiring frequent cleansing. What is the composition of a soap? Irritant and non-irritant soaps. How does soap cleanse the skin? The bath, besides its cleansing effect, is a tonic. Where a bath cannot be taken sponging with woollens or sponge a useful substitute. What temperature should a cold bath have?—What temperature for a warm bath?

How long should one stay in the bath? The temperature of the sea-water in summer, a standard for the temperature of a cold bath.

Clothing.—Good conductors, bad absorbents; danger of chill. Bad conductors, good absorbents; their value for the system enfeebled in anyway, for the young, and for those who take active exercise. Why is loosely worn porous woollen material warmer than close fitting stuff? Injury caused by clothing which constricts the chest and abdomen. Ill-fitting boots.

Preservation of Sight.—Short sight or myopia; easily recognised by comparison with the sight of another person. Long sight, hypermetropia. Is the sight rendered painful after study for a period of an hour or more? Astigmatism.—Take a white paper on which vertical and horizontal lines are drawn in ink. Place this paper on the wall, and look at it at a distance of

18 feet. Are the lines equally distinct? All three conditions necessitate the use of spectacles. Colour blindness.—Take a number of skeins of woollen thread of a great variety of colours and match the colours which resemble one another. Note defect as regards reds and greens. In what occupation is colour blindness dangerous?

III.—HOUSE HYGIENE.

Site.—In relation to soil, elevation, and sunlight.

Air Supply.—The value of fireplaces and of open windows. No bedroom should be without a chimney.

Heating.—The wasteful grate. The economical grate.

The Watercloset.—Its water supply; the trap; the course of the soil pipe; the drain; their ventilation. Danger of sewer gas. What is the dry-earth system? Is there disconnection of drinking water supply, and water supply to the closets?

Sick Room.—Inadvisability of curtains, carpet, dark corners, dust. Advantages of iron bedstead, hair mattress, light and warm coverings; necessity of uniform temperature, and use of a room thermometer.

Sick Nursing.—How to make the bed. Washing the patient. How to measure medicines. The capacity of a teaspoon—a tablespoon. Care of bed sores. Disinfection.

Lighting.—Oil, gas, the incandescent burner.

The Bath.—Its utility. Its situation. Simple substitute for it in small house

IV.—FIRST AID TO THE INJURED.

In part an application of the general principles of physiology; thus, artificial respiration, compression of principal arteries, the placing of a fractured limb in the position of rest with the least movement of the fragments, keeping a fainting person in horizontal position, are cases in point. The use of simple emedies is, however, required in most cases. Whenever the urface of the skin is broken, microbes may enter the system. The treatment of the wound by an antiseptic should be employed. Poultices, fomentations, blisters, substances to produce vomiting, should be known to everyone. As a popular antiseptic the value of boracic acid powder may be pointed out. No household should be without this simple aid. The cyclist should always have it.

Practical Work.—To make a poultice. Have boiling water ready, put the linseed meal into the boiling water and stir till it makes a thick paste. Spread on linen, leaving a margin of one inch free from paste; turn over when the requisite amount of matter is spread on. If the linseed is not convenient, a poultice may be made from bread from which the crust has been removed, by soaking the bread in boiling water repeatedly and mashing to a pulp. The bread should retain its heat for an hour, linseed an hour and a half, or more. Bread is used for small applications, linseed for large. To make a turpentine stupe or fomentation—wring a cloth dry out of boiling water, and spread the turpentine in drops over the steaming surface.

A Mustard Plaster.—Mix the mustard with cold water, and spread on brown paper; when taken off the patient, remove the mustard carefully from the skin.

To Produce Vomiting.—Two tablespoonfuls of common salt in a tumblerful of water, or mustard and water.

Fainting.—Horizontal position, open the clothing over neck and chest, simple external stimulants (cold water, smelling salts).

Fits.—Infantine fits, a warm bath for a few minutes, wrap in blanket, cover well. Apoplectic fit, elderly person falls unconscious and paralysed; complete rest. Do not give stimulants. Epileptic fits—unconsciousness with convulsions; leave patient alone. He will recover soon. Then let him sleep.

Accidents.

Fractures.—Recognised by position and deformity of limb. If it is compound, *i.e.*, with an open wound, fill the wound with boracic acid powder, and send immediately for a doctor. If not compound, place in a position of rest. Take two pieces of light wooden splints, line with cotton wadding, place along the limb extending beyond the joints above and below, and apply bandages to maintain the splints in position.

Sprains.—A joint is strained. It will soon swell; apply a bandage before swelling ensues.

Hæmorrhage.—If a large wound, note if blood spurts. If so, apply a bandage tight around the limb above the wound; stick a piece of wood through the knotted end and twist to apply sufficient compression. If the wound is in the region of the temple, fold a coin in a piece of linen, place it over the wound, and bind a handkerchief around the head to maintain it. If, from a varicose vein, lay flat, and bind above and below the wound.

Burns and Scalds.—Remove the clothes carefully, if necessary cutting them away. Cover the surface well with flour or bread-soda. Put on a soft wrapping and apply a bandage. If a woman's clothes should be on fire, let her fall on the ground, and roll round and round. Heavy wrappings rapidly extinguish flames.

Sunstroke and Heatstroke.—Remove into the shade and strip off clothes. Pour cold water over head and neck and spine from a height of a few feet till patient begins to revive. Then, perfect rest.

Suffocation by Gas.—Let the rescuer take care of his own safety in entering the vitiated atmosphere. Bring the patient into the air, open the clothing, rouse with cold water, and carry on artificial respiration.

Drowning.—Free the mouth cavity, pull out the tongue, undo the clothing over the chest, endeavour to stimulate by smelling salts. Perform artificial respiration, if necessary, for two hours. When restored, apply artificial warmth to lower limbs and abdomen, give warm stimulants. Artificial respiration should include forcible slow compression of the lower half of the chest if a second helper is available, while the movement of expiration is being carried on by the person dealing with the arms.

Point out that the danger of drowning in sea bathing is most frequent in early morning bathing, when one has not first taken a cup of tea or coffee; in case of a weak heart; and from remaining too long in the water.

Poisoning.—Primary rule—find out as soon as possible what poison has been taken, and send for a doctor. Common poisons are strong acids, strong alkalis, carbolic acid, corrosive sublimate, opium, strychnine, prussic acid. Stains about the mouth suggest acids and alkalis. Treat them with olive oil, raw egg. If you know it to be an acid, give lime water. For the sublimate, white of egg. For opium, on no account let the patient fall asleep. Strychnine causes convulsions. Is the production of vomiting indicated in poisoning by acids and alkalis?

APPARATUS AND REAGENTS.

(In addition to the Physical and Chemical List.)

1. A Page gas regulator.
2. A hot-air bath, with water-jacket.
3. A piece of glass tubing bent into a U, 18 inches long.
4. India-rubber tubing, one yard.
5. Five dozen test tubes and racks.
6. Parchment tubing (for dialysis).
7. Dried gut of young animal (dialysis),
8. One dozen dissecting dishes, of metal, filled with paraffin wax.
9. Scalpels, forceps, scissors, strong pins.
10. Preparations of dextrose, lactose, maltose, de Witte's peptone, dried egg albumin, fibrin.
11. Preparations of pepsin, trypsin, and other digestive enzymes (Benger's fluids, or glycerine extracts).
12. Skeleton of human body.
13. Chart showing circulatory system in human body.
14. A clinical thermometer.
15. A few rolls of bandages.
16. Models of water closets.
17. Models of ventilating apparatus, such as Tobin's tube, Sheringham valve, louvre, cowl.
18. A microscope with low and high power objectives to a magnification of 360. (Average cost of microscope about £3.)

(8.)—GEOLOGY.

Introduction.

1. Seeing that Geology is concerned with the explanation of the existing features of the earth's surface, and thus with the past history of the district in which the study is undertaken, the most im-

portant observations must be made in the open air. But any excursion for the study of scenery, and for the collection of illustrative specimens, will provide material for investigation in the laboratory, and for comparison in types in the school-collection. The methods of such investigations will be for the most part familiar from previous chemical or physical work, and scarcely any fresh apparatus will be required. The organisation of the field-work will therefore be the first consideration; but an afternoon excursion of some three or four hours will often prove sufficient for the gathering of a large store of specimens and ideas. When the fundamental principles have once been grasped, every walk, or drive, or cycle-run across country will serve the pupil as a sort of unscholastic but helpful geological excursion; and the teacher may do well to lay stress on the geological features, not merely of the country near the school, but of the places to which the members of his class are likely to resort during their summer holidays.

2. The school should possess a geological map of the British Isles (Keith Johnston's, by Alex. Johnstone, is recommended), and copies of the local Ordnance Survey maps, geologically coloured. These are issued by the Geological Survey of Ireland (through Messrs. Hodges, Figgis & Co., Dublin), on the scale of one inch to one mile; price 3*s.* each. Multiple copies of parts of these can be made on any copying apparatus, for use by the class on field-excursions. On the ordinary gelatine machines, coloured inks can be used for shading the various formations in the copies made.

3. If the Ordnance Survey has also issued contoured sheets for the locality, these will be of great service in determining heights, which are only sparsely given on the geological sheets. For detailed work, one or more sheets may also be required on the scale of six inches to one mile.

4. Throughout the course, photographs or lantern-slides of Irish scenery, such as those issued by Welch, of Belfast, and Lawrence, of Dublin, and of larger scenic features in other countries, will be found of constant service. Each pupil should have a pocket-knife and a common triplet pocket-lens (costing about 3*s.*); any small hammer will serve for simple geological excursions, but the head should preferably have a square flat end for striking with, and opposite to it a chisel-edge, perpendicular to the shaft; the head should be well secured to the shaft by wooden wedges, which can be tightened by leaving the hammer for a time in water.

The Crust of the Earth.

1. The school should possess a collection of the following rock-forming minerals, in specimens about 7·5 by 5 cm., both crystallised and massive. The crystals may of course be shown by smaller specimens. Quartz, chalcedony and flint, magnetite, limonite, iron pyrites (pyrite and marcasite), rock-salt, calcite, aragonite, dolomite, gypsum, apatite, orthoclase-felspar, oligoclase-felspar, labradorite-felspar, augite, hornblende, olivine, muscovite-mica, biotite-mica, almandine-garnet, kaolin, one of the chlorites, serpentine. Also a few models of common natural crystals in wood, to illustrate what is meant by crystalline symmetry, thus:—

2. *Triclinic*; a triclinic felspar. *Monoclinic*; orthoclase; also an interpenetrant Carlsbad twin of orthoclase, as showing the common natural form; Augite; Hornblende; Gypsum. *Rhombic*; Olivine; Aragonite. *Tetragonal*; Zircon. *Hexagonal and Trigonal*; Beryl

(to show full hexagonal symmetry, which is rarely attained by minerals); Calcite (scalenobedron, rhombohedron, and rhombohedron combined with prism); Quartz (with trapezohedral planes on alternate angles, to show how this mineral falls short of complete hexagonal symmetry). *Cubic;* Magnetite (octahedron); Garnet (rhombic dodecahedron); Pyrite (cube, but also pentagonal dodecahedron, to show its falling short of complete cubic symmetry). A contact goniometer is desirable. (See below.) With these specimens and models as a comparative series in reserve, an excursion may be made to collect the materials of the crust. In most districts, few good *crystals* are obtainable; but *rocks* can be brought in for dissection in the laboratory, when it will be found that they are made up of a variety of mineral particles. These, such as the mineral constituents of granite or diorite, can be compared with the standard series; the hardness of grains of sand or the softness of clay-particles can be tested by pressing them between two plates of glass and observing any scratches produced; the specific gravity of, let us say, calcite from a vein can be found on a common chemical balance; and the behaviour of the same mineral in acid may be compared with the inactivity of quartz. Emphasise thus the distinctive characters of *mineral species*, using the pocket-knife and thumb-nail as tests in determining their relative hardness.

3. It will be found, then, that the earth's crust is composed of rocks, and that these are composed of a comparatively small number of mineral species. Point out the characters by which these minerals differ—hardness, specific gravity, behaviour with chemical reagents, crystalline form, cleavage. In dealing with crystalline form, the names of the various planes need not be given; but the grounds of reference of the forms to different systems should be stated. The constancy of angles in given mineral species must be relied on; from these observed angles the wooden models are constructed, in which each face of the same kind is made of the same size. In nature however, this rarely happens; the symmetry of the whole form is spoiled by the unequal growth of the crystal in this or that direction; but the fundamental angular symmetry is not impaired, and remains to indicate the crystalline symmetry that prevails in the arrangement of the molecules which build up the crystal.

4. The constancy of certain angles may be tested with a goniometer on larger specimens in the collection, such as Quartz (angles between prism faces 120°; between adjacent rhombohedron faces 133° 44'); Garnet (in rhombic dodecahedron, between any two adjacent faces 120°); Calcite (over any of the three edges at top or bottom of a rhombohedron, broken out by cleavage, 105° 5'). The instrument known as the *contact goniometer* is easily constructed; but Mr. G. L. English, 812, Greenwich-street, New York, supplies Professor Penfield's types of the instrument in vulcanite and card, for class purposes, at about 2s. each.

5. The fact that many crystals are found "twinned" must be pointed out; also the dependence of cleavage on crystalline form. Cleavage is often of more service than the outer crystal form, which may be undeveloped in a specimen gathered from the rock.

6. In a district rich in *metallic ores*, a few of these may be dealt with, common blow-pipe tests being used in discrimination. Note the occurrence of such metallic minerals locally and in veins. Coal is not to be treated as a mineral, but as a rock of organic origin. (See page 153.)

7. Having obtained some idea of the materials of which the crust is made, the class proceeds to examine their arrangement in the crust. In the rocks collected, the crystalline constituents may be intergrown with one another, as in granite, or may be merely fragments held together by a cement, as in sandstone; or the rock may consist of one mineral massively developed, as in crystalline limestone; or of organic remains possessing a mineral constitution, as in fossiliferous limestone, such as that from the Carboniferous system. *Modes of origin of rocks*; some are stratified; some must be compared with the crystalline slags of furnaces, and have similarly consolidated from a molten state. How can their characters be explained? The class must observe the processes that are every day at work, making and unmaking rocks in the world around us.

The Slopes of the Hills; atmospheric agents that attack the Crust. Weathering of rocks.

1. In a road-side cutting or a quarry, note the passage from the solid bed-rock into loose broken rock, and then into *soil*. The surface soil may sometimes have been brought from a distance by the wash of rivers, &c.; but any rock-mass left to the action of the atmosphere will break up into its proper soil. Note how, in the case of a decomposing granite, all the constituents lie scattered about the surface, the felspar showing most evidence of decay; how slates and shales yield up a sticky clay; how limestones often yield only a thin sand or clay, which is merely their insoluble portion, the mass of the rock having been carried away in solution. Illustrate by dissolving any common limestone in acid, and examining the washed residue with a lens or microscope.

2. Describe the action of gases in the atmosphere on rocks; of rain and frost; of wind, laden with sand-grains like a sand-blast. Carving of pinnacles and gullies on exposed hill-sides. Heaps of *débris* (*taluses*) on mountain slopes. Show the nature and conical form of these in the field, and how farmers lay hold of them ultimately in mountain districts for cultivation.

3. *Landslips* assist the decay of a hillside; illustrate by slips in artificial banks or cuttings.

4. *Snowfields and glaciers*. Scratching of rocks under the moving ice. The action of glaciers is mainly one of transport; vast amount of material carried in or on the ice; appearance of this at the foot of the glacier, or as the whole ice melts finally away during a warmer period. Contribution of glaciers to the soils of Ireland; distribution of *boulder-clay* and *glacial gravels* as "drift" over the country. Origin of *eskers* and "green hills" in stream-tunnels under a great glacier. Traces of ancient glaciers in Ireland seen in the rounding and scratching of the rock-masses. Origin of *cirques* and mountain lakelets. Illustrate by photographs of Alpine and Arctic scenery, and, where possible, by visiting a drift-covered area and collecting scratched pebbles from it; clear the deposit away in part, so as to reach the underlying and smoothed rock-floor. Shew pictures of rock-surfaces smoothed by ice-action in various parts of Ireland, such as Kerry or Connemara.

5. In conclusion, it will be seen that the precipitated moisture of the atmosphere, aided by the action of frost and wind, is responsible for most of the loose materials that lie upon the surface of the crust; and that these are derived from the decay of older solid masses. Examine soils and gravels by washing through sieves, and endeavour to trace the materials back to their parent rocks

6. *Apparatus required.*—Test-tubes or dishes, for dissolving limestones in hydrochloric acid. Simple microscope and glass-slips for examining residues and soils. Set of sieves, fitted together in series, with zinc floors pierced with circular holes; these are preferable to the ordinary wire-net sieves, as the diameter of the largest particles which pass through any sieve can be accurately known by the diameter of the holes; four sieves, about 12 cm. diameter, with holes respectively 5 mm., 2 mm., 1 mm., and 0·5 mm. in diameter, will suffice for ordinary operations.

The Action of Rivers.

1. In field excursions, note how streamlets arise on hillsides from the union of the trickling waters within the soil, or within mountain-bogs; how they are conspicuous after rain, and how they persist long after the rain has passed away. In many cases, the area drained by such a streamlet may be large enough to keep the water running between one rain-storm and another, without the help of subterranean springs. In other cases, the water that falls on one area emerges as a *spring* at some other place. If the source of the main river of the district cannot be visited, some tributary can generally be utilised. In limestone districts, note the disappearance of streams into solution-hollows, and their reappearance from underground channels. Lakes often supply a district with a large river, ready made, as it were, at its source.

2. Note how *débris* may accumulate on the floor where a tributary emerges on the main stream, or where a stream flows into a lake. Whence does this material come? Observe the clouding of the waters after heavy rain by *material in suspension*. Collect the water and allow it to settle; then filter, and evaporate. A second sediment is thus secured, which represents the *material carried invisibly in solution*. Now perform the operation quantitatively. Show how, by measuring the area of the cross-section of a small stream at some convenient point—*i.e.*, determining its width from bank to bank and the form of its bottom, and constructing a diagram to scale on paper ruled in squares, each representing one square decimetre—and by noting its rate of flow in decimetres per hour, the number of litres of water that pass the given point in an hour can be ascertained. From this calculate the number for twenty-four hours; show how, by observing the variation in flow and in the height of the water-level every day during a whole year, the flow of water for that year may be known; if the observations are continued for a series of years, the average flow per annum is found. If these observations are accompanied by determinations of the amounts of material carried in suspension and solution, the work of the river in *denuding* the land above the point selected can be estimated for an average year. All this material comes from the rocks of the river-valley. Unexpectedly large results are thus obtained.

3. Note also stones at bottom of stream, moved easily by it in times of flood. These are gradually rounded by friction on one another, and form *pebbles*. Action of the fine suspended material in polishing these stones and helping the cutting action of the stream, like emery-powder or sand in a stone-cutter's yard. More obvious and violent action in waterfalls. Pebbles stick in clefts of rocks, and drill out *pot-holes*; these unite, and whole blocks of rock are broken down. Origin of the deep pools under waterfalls.

4. *Relation of the stream to its valley:* Given the slope for it to start on, the stream slowly cuts out its own valley. *Ravines* imply

rapid action; assistance is given by joints or planes of weakness in the rocks attacked. The rain smooths back the valley sides. Huge gorges arise where the river runs steeply and thus cuts rapidly, or where the rainfall is so small as to leave the vertical saw-action of the stream unmodified. The great cañons of America occur in practically rainless region; those of the Alps are due to extremely rapid stream-action, which keeps ahead of the smoothing and widening action of the atmospheric waters.

5. Formation of *deltas* in lakes, and *alluvial cones* on hillsides, where much material is washed down and cannot be carried away. Choking of a valley; *alluvial flats*. Note how the green meadows by the stream contrast often with the valley sides. Observe their pebbly or muddy materials. The stream wanders in loops and bends in the alluvium, often changing its course at some newly-deposited obstacle, and leaving old tracks behind it. Note cutting action on one bank, and alluvial deposit or pebble-shoal on the other. The stream is swinging towards the bank where the little excavated cliff appears.

6. Rock-masses formed by consolidation of alluvium. Sometimes the stream clears out its hollow again, leaving its old alluvium as a *river-terrace* on one side or on both. A succession of infillings and clearances produces a series of alluvial terraces at various heights. The causes of these changes are very various. A valley may be choked because a large amount of loose material lies up-stream, easily removed even by a river of moderate flow; when this has been swept down into the lower part of the valley, choking the stream and producing an alluvial flat, hard rock alone remains up-stream, and the pure water, less highly charged and no longer over-loaded, cuts in its lower course into the material it previously laid down. Or a climatic change causes greater flow, and consequent sweeping out of the alluvium. Illustrate by the local variations in stream-deposits, as noted in successive visits. A talus-fan formed during the flooding of some side stream, often becomes cut away later, when the rush of loose material has ceased. The same facts are seen under hedge-rows, and in road-cuttings, after rain.

7. *Effects of earth-movements on the cutting power of streams*; elevation of a country allows of deeper excavation. Depression below sea-level of course checks excavation in the portion of the valley flooded by the sea. Formation of long lakes by warping of valley-floors, and of *fjords* by submergence of valleys below the sea. *Islets* arise thus, such as the Skelligs or the Blasket Islands, and represent peaks that stood on the old valley-walls.

8. *Apparatus required.*—Evaporating dish, filter, &c., for river-water. Balance for the quantitative work. Measuring-tape for field-work; objects, such as pieces of white wood, to float on stream in observing rate of flow. As the flow of a stream varies in its different levels, a weighted rod is preferably used, reaching nearly to the bottom of the stream and floating upright in the water; this moves with the average velocity. (For illustrations, see *Encyclopædia Britannica*, 9th Edition, pp. 505-6.) Sieves for examination of alluvium, as in the previous section.

The Action of the Sea.

1. In studying what goes on upon a sea-shore, the same observational methods may be pursued as in the case of the stream. The sands may be sifted, and this or that constituent may be picked out. Note the great preponderance of

the more resisting materials, and how muds and fine limestone particles are floated away out to sea, leaving pebbles of quartzite (as in Co. Donegal), or flint (as in Co. Antrim), or jasper and quartz-rock and granite (as in Dublin and various counties of Ireland), to form beaches against the coast. The *sand* itself is a witness to the same natural processes of separation; the insoluble and resisting grains of crystalline silica remain behind in excess, and form our sandy stretches in the quiet bays. Compare these deposits with *Sandstone* and *Conglomerate*. Origin of these rocks in seas or lakes.

2. The winds seizes on the sands and piles them up into *dunes*. Note the constant struggle between the wind on the one hand, and the growth of bent-grass and other vegetation on the other. Movements of dunes, and their characteristic forms.

3. Note how *shells* accumulate at certain places. Ordinary marine sands of barren aspect yield numerous shell-fragments, and generally well preserved foraminiferal shells, when the sand-grains are sifted away. Show how the shells consist of calcium carbonate (using ordinary chemical tests), together with a certain amount of organic residue on solution in hydrochloric acid; this residue varies, with their degree of freshness. Discuss the relation of the shells to various organisms—foraminifera, sea urchins, bivalve and univalve molluscs, and crustacea. Brachiopod shells are rare on our coasts, but common elsewhere; these animals were abundant, however, in past times in Ireland, and even predominated in early days over the molluscs.

4. *Corals* and *calcareous seaweeds*.—Formation of reefs. Point out that the coral-polype is neither an "insect" nor "industrious," but that the reef results from the accumulation of coral-skeletons, infilled with calcareous seaweeds and foraminiferal deposits. Limits of coral reefs at the present day. Calcareous seaweeds of Ireland. Their use in the West for manuring land poor in lime.

5. Origin of most *limestones* in accumulations of the hard parts of marine organisms. Examine shelly limestones, such as the common Carboniferous Limestone of Ireland or the White Limestone of the North. A section under the microscope shows the whole mass to be of organic origin (here and there, recrystallisation of the aragonite or calcite of the original shells has destroyed the outlines of the organisms, and a less altered mass must in such cases be selected). Note how the *fossils*, the hard remains of dead organisms, often stand out on weathered surfaces of the rock, although the mass looks compact and inorganic in origin when freshly broken.

6. Origin of *stratification*. Thin but regular deposition of material in the oceanic regions remote from the actual coast. Limits of deposits formed of material washed down from the land. Only organic calcareous and siliceous deposits, and red clays derived from the decay of floating volcanic ash, are laid down in truly oceanic waters.

7. Examine various marine *sedimentary rocks*, so as to become familiar with their characters. Sandstone, clay, shale, limestone; foraminiferal and other deep-sea deposits, examined with the microscope.

8. The action of the sea as an accumulator and store-house of materials from the land has been dealt with first, since this is its most obvious aspect on an ordinary shore. But the sea is a powerful agent of denudation, and supplies a vast amount of detrital material to itself. Observe the results of storms. *Undercutting of cliffs.* Formation of *caves*. *Sea-stacks and pinnacles*. *Origin of bays*. Marine action is assisted where, by movement of the earth's crust,

the shore is sinking. *Raised beaches*, on the other hand, indicate elevation of the land; distinguish these from the accumulations thrown up above ordinary high-water by storms.

9. The foregoing matters can be brought out one by one in visits to the coast; where these are impracticable, samples of beach-deposits, pebble-banks, &c., should be obtained from some familiar Irish seaside resort, and the various components traced to their sources, organic or inorganic.

Plains and Deserts.

1. Relations of Plains and Deserts to adjacent hills. Study of maps of the various continents. *Growth of alluvial deposits in the lowlands.* Conversion of plains into deserts by climatic changes. *Salt-lakes* in arid regions; origin of rock-salt and gypsum beds. Ancient desert and salt-lake deposits near Carrickfergus. Sand-dunes in deserts.

2. Some plains are the floors of ancient seas, not yet folded by earth-movements or cut into by denudation.

3. Illustrate by specimens of Triassic sandstone and salt and gypsum from north-east Ireland. Show under the microscope the remarkable roundness of sand-grains from the Egyptian desert, or other region where the sand is in continual movement under influence of the wind.

Vegetable Deposits.

1. Action of vegetation in assisting the formation of soils. Note the wedging action of roots in road-cuttings or old hedgerows. Visit *peat-bog* and collect from the successive layers; note how the water prevents the scattering and free oxidation of the decaying vegetation; hence low-growing plants that love water have the best chance of forming permanent carbonaceous deposits. Observe, where the bog is cut away, the old floor on which it rests; often a layer of shelly limestone-mud is found, representing the floor of an old lake, on which the vegetation gradually encroached.

2. Plants that form peat or "turf"; swamp-vegetation in other countries; forest-deposits. Flotation of trees to the mouths of rivers; estuarine carbonaceous beds thus formed, interstratified with sands and clays.

3. *Coal* of various geological ages. Plant-remains best seen in the associated shales and sandstones. *Anthracite.* Coal-bearing areas in Ireland.

Diatomaceous deposits. "Kieselguhr." Illustrate by the kieselguhr of the Bann, Toome Bridge works, Co. Antrim (examine also with high power of the microscope).

Igneous Rocks.

1. *Volcanic action.* Tuff and ash. Lava-flows. Columnar structure. Crystals develop during cooling of the lava. Illustrate by specimens of crystalline groups often seen in glass from glass-works, or in slags from metallurgical furnaces. If polarised light is obtainable in connection with the microscope (an instrument with Nicol's prisms may probably be borrowed for this occasion), cross the Nicol's prisms, so as to produce darkness; then insert a plate of glass, to show that no change results when a non-crystalline body is introduced; then a plate of mica, to show that a crystalline substance may affect polarised light in such a way as to restore light between the crossed nicols. This enables the following experiment on *crystallisation from fusion* to be appreciated :—

Melt a little candle-grease on a glass microscope-slip, and cover with a cover-glass so as to make a thin film of grease. Place between crossed nicols, and observe that the molten mass behaves as a glass and produces no change. Watch the production of crystals as cooling proceeds; tiny rods of stearic acid separate out, ultimately forming a dense mesh; each crystal restores the light between the crossed nicols, and the first ones thus stand out brightly on a dark ground. The development of a crystalline mesh from a molten silicate magma in a lava-flow is thus well exemplified. *Minerals of the lava-flows*; *residual glass* occurs also in most cases.

2. Accumulation of materials, by explosion or gentler protrusion, to form *volcanic cones*. Extinction. *Geysers and mineral springs.* Slow cooling of igneous masses underground. Deep-seated igneous rocks, only revealed by denudation. *Dykes and larger intrusive masses.*

3. *Types of igneous rocks.* Granite; Diorite; Olivine-Gabbro. Rhyolite; Andesite; Dolerite and Basalt.

4. *Recognition of old volcanic areas.* Relics of lava-plateaux. The Giant's Causeway, and general phenomena of north-eastern Ireland.

Granitic rocks in Ireland. Granites of Donegal, Galway, the Leinster Chain, the Newry Axis, the Mourne Mountains. Carlingford Mountain; Slemish, and other masses of gabbro and dolerite.

5. *Illustrations.*—Excursions to any accessible igneous masses, such as the area between Croom and Limerick, the granite of Dublin and Wicklow, the Mourne area, and especially the counties of Antrim and Londonderry. Collect the rocks in place, if possible, and compare with a representative collection of igneous rocks. Note their distribution on the geological map of British Isles. Study them by comparing their texture or degree of crystallisation; the specific gravity of specimens of similar texture but different chemical composition; their mineral constitution, seen on breaking up the rock, sifting, and examining the finer particles, mounted in water, under the microscope. Explain the principles of the preparation of rock-sections for the microscope, and show some six or seven such sections. Polarised light need not be used, and only the degree of crystallisation and the general structure need be insisted on. Every microscopic section should be regarded as part of a rock-mass, and that mass as a definite portion of the earth's crust. Avoid elaborate terms in describing rock-structures, lest the pupil—who is not going to be a professional geologist—comes to regard geology as an exercise in classical terminology, rather than as a study dependent on the open country. The igneous rocks suggested for examination in microscopic section are:—Granite; Diorite; Olivine-Gabbro; glassy Rhyolite (Pitchstone or Obsidian); Andesite; Dolerite or Basalt.

Movements of the Earth's Crust.

1. Refer back to Raised Beaches ("Action of the Sea," par. 8.) *Upheaval and subsidence* at the present day. *Earthquakes* are probably incidents in general slow movements. Marine fossils, as already seen, show that land and sea have changed places in the past. *Uplifting and folding of strata* show that the solid crust has been raised above the sea, the sea at the same time withdrawing into new hollows provided for it by subsidence. *Strike and Dip.*

2. Measure dip in the field. Clinometers are easily made by mark-

ing a graduated arc on a card and suspending a little weight by a thread from the centre from which the arc has been drawn. Mark 0° at the apex of the arc, and 90° at the ends of the horizontal diameter. Show line of strike by a spirit-level and a rod, moving latter about on the dipping surface of a bed with the level on it until it lies horizontally. The direction of the rod then gives the strike. The true or greatest possible angle of dip is the angle made with the horizontal by a line perpendicular to the strike, and also lying in the surface of the bed. Set, then, the plane of the clinometer-arc perpendicular to the strike-line, and note true dip. Determine dip also as seen on a quarry-face or a natural section.

3. *Types of folding. Faults and overthrusts. Unconformity.* The gravel-capping on an Irish limestone-quarry is usually seen to be unconformable with the stratification of the underlying limestone.

4. *Structure of great mountain-chains.* Illustrate by folding a cloth, or layers of thick felt piled on one another. Show with a large crumpled cloth how anticlinals and synclinals die away at their ends on the earth's surface. Weathering of uptilted masses; *escarpments and dip-slopes.* Models may be made with layers of coloured clay or plasticine, and cut away with a knife to show the effects of denudation.

5. The geological maps of southern Ireland illustrate most of the features of mountain-folding. The pupils should learn at this stage to draw sketch-sections from the maps, so as to show the arrangement of the rocks below the surface.

Metamorphism.

1. Alteration of rocks under internal heat and pressure. *Baked rocks.* Altered limestones on the sides of dykes in Co. Antrim. Mica-schist as a product of *contact-metamorphism.* Compressed rocks; *slate.* Metamorphic *cleavage.*

2. *Foliation.* Crushing of ancient igneous rocks. Types of *schist* and *gneiss.* Development of minerals in these.

3. *Illustrations.*—Specimens of Irish metamorphic rocks. Excursion to igneous junctions, such as intrusion of granite in mica-schist at Killiney, Co. Dublin, if possible. Also to areas of ancient rocks, such as those in the highlands of Galway, Mayo, Donegal, or Londonderry.

The Geological Record.

1. Value of fossils in reading the past history of stratified rocks, and consequently of the district in which the school is situated. Succession of life-forms upon the globe. Observations of William Smith in 1798. *Systems* of strata. *Geological periods.*

2. Difficulty of estimating the time represented by any geological period. *Succession of the systems,* from the Cambrian to the present day; faunas and floras characteristic of each. Steady progress towards more specialised types of life.

3. *Systems represented in Ireland.* Gaps in the record; comparison with England and with Scotland. Geological relation of the British Isles to the continent of Europe.

4. Illustrate by bringing together fossils from different horizons. In the north of Ireland this can conveniently be done by actual field-collection in a limited area. Elsewhere, the local collection may be formed and may be compared and contrasted with other representative series. Drawings of fossil reptiles and mammals should be shown, as these types are essential to a realisation of the fauna, although

their remains are comparatively rare. The *species* of fossils found locally may be discussed, and the value of species in marking out *zones* may be pointed out; but otherwise only the broad aspect of a fauna need be dwelt on, and even generic characters should be sparingly introduced. The young worker who has acquired the names of fossil species very rarely knows the grounds on which any one species has been established; and experienced geologists are naturally and properly accustomed to check the species in their collections by comparison with the original descriptions. This cannot well be done away from public libraries; and hence the learning of lists of fossil species during school-work is merely an encouragement to self-deception. Every specimen that is handled should be made of some service in conjuring up a picture of the past—in making the pupil realise the strange vicissitudes that any common plot of Irish land has undergone. At the same time a lasting impression will be gained of the long chains of life-forms that lead up to the familiar fauna and flora of to-day.

(9.)—DRAWING.

SUGGESTIONS FOR THE TEACHING OF DRAWING.

Elementary Freehand.

The drawings should be made on plain paper, either in books or on separate sheets, of about quarter imperial size, *i.e.*, 15 inches by 11 inches; thin and soft paper should be avoided. When separate sheet are used, it is advisable to keep the drawings in portfolios or large paper envelopes, which can be made by the pupils.

The course should be carefully graduated according to the ability of the class, the work of one lesson indicating to a considerable extent what is best for the next. Drawings should always be made larger or smaller than the originals; never of the same size.

The collective method of teaching will be found best when the classes are large and the capacity of the pupils varies considerably. If the examples are well selected, it will be found that all the pupils have to grapple with the same difficulties to a greater or less degree. To draw the simplest example well, will require careful attention from even the best pupils; the slower pupils should be able to get through the "setting-out," and also to complete a portion of the drawing in detail.

A large diagram should be placed in front of the class, so that each pupil may have a front view. If the room is wide, two or three examples may be required. Before drawing is begun, the example should be carefully studied by the pupils with the help of the teacher, who should point out the importance of noting the structural lines and proportions at the beginning. The teacher should also draw attention to the principles of ornament illustrated, and the use to which the piece of ornament might be put in design. He should then make a sketch on the blackboard, showing the leading lines. (The pupils should make their drawings from the original; the teacher's drawing having been removed.) The structural and leading lines should be sketched in light continuous lines, and not in short unmeaning strokes or dots.

If the example is symmetrical, the centre line should be drawn first; next the leading line on the left-hand side, then the corresponding line on the right; and so on, from the largest parts to the smallest detail. Should the example be unsymmetrical, the structural lines and general proportions should be set out first, and the details should follow. Pupils should be encouraged to hold their drawings at arm's length occasionally, so as to test their estimate of the proportions, the direction of the leading lines, &c.; they should also test the proportions by means of the upheld pencil or ruler.

If the leading lines and proportions are put in with faint but discernible lines and the drawing is planned from the largest masses to the smallest details, as described above, it will not be necessary to erase the first sketch; the finished lines can be put in directly, and there will be no necessity for the so-called "lining in."

The rubber should be used as little as possible; and it would be well to have an occasional lesson in which its use is prohibited.

Though it is often necessary for the teacher to work on pupils' drawings, both to correct errors and to show how the pencil should be used, it is usually best to illustrate general errors on the blackboard and only individual errors by slight sketches on the margin of the pupil's drawing. Attention should be called not only to the difference between the pupil's work and the original, but also to the principles violated.

Some of the best pupils, who, as a rule, finish their drawings before the end of the lesson, might, with advantage, be given an exercise in simple design, or set to line their drawings with the brush, or to tint them with water-colour or crayon. If crayon is used, the colour should be put in with the point in parallel lines, the direction of which might be varied in the spaces at the opposite sides of a symmetrical example. Such lines in any one space should, however, be parallel throughout that space; the colour should not be put in with a rag or stump. The result should be clear and precise. Exercises in drawing with chalk on the blackboard to a large scale, might with advantage be carried on concurrently with Freehand, Model and Object Drawing, and Design.

Simple Exercises in Design.

To avoid misunderstanding, it is explained that, while the term "Design" ordinarily connotes invention, it is employed here in a much more restricted sense. The faculty of invention is a natural, and not an acquired, power; but, by affording scope, under proper direction, latent capacity for invention may be developed. It is therefore clearly not intended to teach invention, nor even to study how designs may be executed in crafts: it is only proposed to provide exercises in simple composition and arrangement—pattern-drawing, as it is often called—and to show by the application of the rules of composition (repetition, alternation, &c.), how ornamental forms can be constructed by means of simple elements. The main object of the lessons is to capture the pupil's interest, to make him feel that he is throwing his personality into the exercise, and that the difference between his result and that of his neighbour is one due mainly to his own individuality. Individuality may be shown even in drawing a straight or a curved line; but a pupil's "joy in achievement" grows as, aided only by the rules of composition, he creates his own effect. The teacher in this way enlists the most valuable assistance in the study of Drawing—the pupil's co-operation.

Squared paper, in which the squares are not less than 1-inch side, may be used at the beginning.

The teacher might draw a design for a border (composed of a few horizontal lines with squares between) with coloured chalks on the blackboard; this should be copied by the pupils with water-colour or coloured crayon; the colouring should be done with the point; rulers and set-squares may be used. The pupils should then be set to make a new design, using the same elements and following the same principles.

Another form of exercise is to be set at Freehand pattern to be copied, and to instruct the pupils to make a variation on it; or, if the pattern forms a suitable unit for repetition, to make a design for a border or other repeating pattern based on it.

Another suitable kind of exercise is to form simple geometrical shapes by means of compass and ruler, and to draw Freehand forms within them, filling in with flat washes of colour.

Simple designs may also be made by means of brush impressions and strokes on the squared paper.

Natural objects are the best guides to good colour; such objects as stones, shells, feathers, birds, plants, trees, flowers, leaves, &c., offer endless suggestions. The exercises in composition, after being carried to a certain stage in the class, form convenient subjects for home-work. The teacher will criticise these exercises with sympathy, and will also exhibit good designs for comparison.

Object Drawing from the Flat.

Object Drawing from the flat as a variation of Freehand is to be confined to the first year of the Preliminary Course. The school should be provided with a good set of examples of common objects for the guidance of the teacher, and the teacher should always exhibit the real object alongside of the Drawing, and should point out its peculiarities, contrasting it with similar objects. Object Drawings of this character should be made from the teacher's drawings on the blackboard, or on large sheets of paper with charcoal. The use of guiding lines should be strictly limited, and as soon as possible avoided, since they tend to throw the pupil's mind off the form under consideration.

The examples used in Freehand and Object Drawing should be varied as much as possible. Freehand examples should be copies (or photos) of good ornament, and the common objects selected should be of good artistic form.

Memory Drawing.

Memory Drawing is, perhaps, the most important branch of the course in Drawing; its value can hardly be over-estimated.

In drawing from the flat, or from an object, the necessary facts may be noted singly and transferred to paper, each as it is correctly appreciated. In drawing from memory all the necessary facts must first be gathered in by the eye. It will thus be seen that Memory Drawing necessitates keen and intelligent observation on the part of the pupils in order to gain correct impressions. It excites their interest, and leads to a spontaneous and freer style of Drawing than mere copying does; the lines drawn are usually better than those of the Drawing lessons from examples or models; while the pupils' minds are intent on remembering the form, they do not think too much of the lines. It is one of the best means of measuring the technical ability of the pupils, and of testing how much of a lesson they have learned.

Pupils in this way gradually gain the power of rapidly seizing and retaining the essential features of pieces of ornament, objects, &c., thereby laying up a store of ideas, which is of the highest importance in design. The best and most original designs are made by persons who, among other qualifications, know most about the history of Ornamental Art, and have studied the best examples.

It is advisable to have special books or paper for Memory Drawing.

In the early stages the last ten minutes of a lesson may be devoted to drawing from memory the example just completed from a pattern.

The next step might be to draw from memory the example studied at the previous lesson. Further, an example might be exhibited for a short time, and the pupils should be required to give expression to the idea left on their minds.

The examples used should be those previously studied in Freehand, Object Drawing, and Design; pupils might also be instructed to do some Memory Drawing as a home exercise; they should also be encouraged to draw familiar objects, such as pieces of Science apparatus, domestic objects, farm utensils, portions of buildings, &c., &c.

In drawing complex objects from memory, the greatest attention should be given to the structural lines and proportions.

Freehand from the Cast.

The same general principles should govern this subject as those set forth for Freehand from the flat. The models should be good casts of ornament in low relief.

Pupils who have mastered the proper method of setting out, and can make a drawing, which is good in construction and proportion, might be allowed to finish their work with a pen or brush outline.

Design based on Natural Forms.

The geometrical basis of a design should always be carefully drawn with instruments. In using natural elements, the special character of the forms used should, though treated ornamentally, be maintained as far as possible: for instance, stiffly growing plants should not be forced into lines suitable to trailing or creeping plants. Some limitations should be laid down for each exercise, *e.g.*, in outline; in monochrome of one, two, or three tones; in two or more colours, &c. Exercises in repeating patterns should be practised, *e.g.*, running borders and all-over patterns, and also the filling in of such geometrical spaces as the square, rectangle, triangle, circle, &c.

Model and Object Drawing from the Round.

In drawing from common objects and from geometrical models, pupils should be seated so as to face the models directly, and at sufficient distance to see the whole model or group of models. In schools which are provided with single desks this can easily be done by placing the desks in a circle round the models. Where the desks are long and paralled to each other, the pupils should be provided with drawing boards, and should sit so that the top edge of the board is at right angles to "the line of sight." The first lesson might with advantage be devoted to demonstrating the use of the pencil in making comparative measurements, and to securing the direction of lines; it should be made clear that the pencil must always be held at the full length of the arm, and in a plane at right angles to "the line of sight." To obtain the pencil in this position it would be well to require the pupils to hold it between the tips of the first fingers of each hand. At first only large models or objects should be used. A large circular board freely suspended in a horizonal position, so that it can be placed above or below the level of the eye, will be found most suitable, as it can be arranged in such a manner that all the class have so nearly the same view that general instruction is possible. Such models as a door first closed, then open; maps; a blackboard first vertical, then laid horizontally; the cube, rectangular prism, &c., should follow. The geometrical models are recommended because their severely simple form enables teachers to demonstrate principles from them without confusion; it should be pointed out how the principle learned from the study of these type forms may be applied to the drawing of common objects of similar form; and teachers might show how easily a well drawn cube may be made into a well drawn chair or stool; in fact, what slight changes or additions will make the drawings of geometrical models good drawings of familiar objects. In correcting Model or Object Drawings the teacher should be careful to place his eye in the same position as was occupied by that of the pupil when the drawing was made.

Memory Drawing in this subject should be practised.

Shading.

The paper used should not be too smooth. "Whatman's Not," or some similar kind, will be found most suitable.

The point or stump may be used.

At first a few exercises might be worked from the flat; the teacher might draw three squares and fill in each with a flat tone; the pupils should then try and match these tones. When they can do this fairly well, they might be instructed to copy a square in which the tone is graduated from high light in the top left hand corner to dark shadow in the lower right hand corner. After a few exercises of this kind models should be used; such a model as a white cube, hexagonal prism, or a truncated square pyramid on a square slab, would be best to begin with. The model should be placed in a strong light from one source, and studied as a whole before commencing to shade. The same general principle should be followed in this as in all Art work, *i.e.*, first obtain the general effect in the simplest manner possible. This is usually done by working from the largest masses to the smaller details, and from the broad divisions of light and shade to the half-tones.

The school should be provided with casts of fruit, flowers, architectural details, &c., in high relief and the round.

Teachers should point out that the same general methods should be employed in shading casts of apples, oranges, &c., as are employed in shading a sphere.

Modelling.

Modelling should be taught concurrently with practice in Freehand and Model Drawing.

Clay is the best material to use, but where little modelling is done plasticine will be found a good substitute.

Ordinary roofing slates or boards should be used for working on.

The first lessons might be devoted to demonstrating the nature of the material and to the modelling of simple mouldings; a cavetto might be taken, and the teacher should draw an elevation and section on the blackboard, and model it on a large scale before the class. The work should be built up bit by bit by means of the thumb and fingers, tools and carving being used as little as possible. The next step would be the enrichment of these mouldings either by means of incised lines or by the application of simple geometrical forms in low relief.

The modelling of simpe rosettes should follow. From this stage onward the work should be done on clay or plasticine slabs spread over the slate or board, casts of human features and of good ornament in different styles being used as examples.

Design should be practised by making variations on the examples copied, and by the application of natural forms.

Geometrical and Mechanical Drawing.

The most important points to be considered in this work are—correct knowledge of geometrical definitions, accurate measurement, the proper use of instruments, and clearness and sharpness of line. In the first stages drawing-books may be used; the correct use of rulers, set squares, simple scales, and compasses should be taught.

When the "T" square is used (its use should be taught as soon as possible) separate sheets of paper will be found more convenient than books, and drawing boards will be necessary. Pupils should be provided with a suitable hard pencil, and with compasses furnished with a hard pencil point. These should be properly sharpened, as on this to a great extent the neatness and accuracy of the work depends. The ruling of the page into several rectangular compartments also adds to the neatness of the work.

In teaching Geometrical Drawing, even in the earliest stages, its practical application to the setting out of Ornamental patterns and to the drawing of machine and building details should be pointed out. For instance, when the pupils know how to construct a scale of, say, one inch to one foot, and to draw a rectangle by means of that scale, the teacher should ask the pupils to measure the door or window opening of the school, and then make a drawing of it, using the scale which they have constructed. Next, the door with its panels, or the window, with its panes of glass, might be drawn; then pieces of the school furniture, and so on, perhaps, to the plan elevation and section of the school building. Such models as the hinges of doors and gates, bolts, &c., might also be drawn to scale, and in schools which possess models, or real pieces of machinery, these should be drawn to scale.

A hinged blackboard will be found most useful in teaching Solid Geometry, and pupils should be encouraged to make paper or card-board models to help them to understand the problems under consideration.

Teachers should always be careful to choose simple models to begin with, and to have their course of instruction carefully graded.

THIRD YEAR SYLLABUS.

Division I.

Freehand in outline from Casts in low relief, or Modelling from the Cast; or both.

Simple Design, drawn or modelled, based on natural forms.

Model Drawing from geometrical models and familiar objects—not more than two models (or objects) and the board in one group.

Memory Drawing, or Modelling from Memory.

Note.—Studies in Outline of Plant Form from Nature (or Modelling Plant Form from Nature) may be made in conjunction with Outline or Modelling from the Cast.

Division II.

Geometrical Drawing, based on the constructions involved in the following:—

(1.) Constructions required in geometrical pattern-drawing simple tracery, and mouldings.

(2.) Construction of regular polygons—general and special methods; inscribed and circumscribed circles; simple cases of rectilinear figures described in or about other rectilinear figures.

(3.) Circles—passing through three points—touching three lines; tangent lines and circles to one or two circles.

(4.) Ellipse: method of construction; drawing its tangents and normals.

(5.) The construction and measurement of angles by the use of protractors. The construction of triangles from given data.

(6.) Construction of irregular polygons from given data. Similar figures—equal, enlarged, or reduced.

(7.) Plain and diagonal scales and scale of chords; proportional division of lines, including the mean, third and fourth proportionals; reduction of polygons to triangles of equal area; construction of parallelogram or square equal to a given triangle or other rectilinear figure.

Solid Geometry: plans and elevation of cube, prism, pyramid, cone, and sphere in simple positions; and sections by vertical, horizontal, and inclined planes.

FOURTH YEAR SYLLABUS.

Division I. (Boys and Girls.)

Model and Object Drawing, more advanced than that required for third year.

Drawing in Light and Shade from the Cast and from Common Objects, and Design; or Modelling from the Cast, and Modelling Design.

Memory Drawing, or Modelling from Memory.

Note.—Studies in Outline of Plant Form from Nature, or Modelling of Plant Form from Nature, more advanced than those of the third year, may be made in conjunction with Model and Object Drawing or Modelling.

Division II. (Girls only.)

Geometrical Drawing.—The application of third year work to common objects, and the setting out of ornamental patterns, &c.

Division II. (Boys only.)

Geometrical Drawing.

The application of third year work to common objects, simple machine or building details, and the setting out of ornamental patterns, &c.

Drawing from measurements and sketches made by the pupils themselves.

Solid Geometry.

1. The Principles of Projection; definitions of terms in general use, such as ground line, or xy line, projector, plan, elevation, section, trace, planes of projection, &c.

2. Representation of a point in space, by its plan and elevation, in all possible positions with respect to the planes of projection.

3. Representation of vertical and horizontal lines.

4. Given the plans and elevation of a line, to determine:—
   (*a*.) The traces of the line.
   (*b*.) Its true length, and its inclination to each plane of projection. Conversely determine the projections of line when its inclination to each of the planes of projection is given.
   (*c*.) A new elevation of the line on any assigned ground line.

5. Determination of the real angle between two lines which meet.

6. Representation of parallel lines.

7. Simple problems relating to lines.

8. Representation of a plane by its traces:—
   (*a*.) At right angles to one plane of projection, and inclined at any angle to the other.
   (*b*.) Perpendicular to both planes of projection.
   (*c*.) Parallel to the ground line.
   (*d*.) In any position with respect to the planes of projection.

9. Given the traces of a plane, to determine its inclination to each of the planes of projection.

10. Determination of the intersection of two given planes.

11. Determination of the intersection of three given planes.

12. Dermination of the real angle between the traces of a given plane.

13. Determination of the angle between two given planes.

14. Determination of the intersection of a line and a plane.

15. Determination of the projections and real length of a perpendicular let fall from a given point on a given plane

16. Determination of horizontal lines, and of lines of given inclination, in given planes.

17. Simple problems relating to planes. Plans, elevations, and sections, of the solids, enumerated for third year, in more difficult positions.

LIST OF SUITABLE EXAMPLES, BOOKS, &c.

These lists of examples, books, models, &c., have been drawn up to help managers of schools in selecting equipment for their Drawing Classes. *They are solely for guidance and are not listsof requisites.*

FREEHAND DRAWING.

(*a.*) The "Design" Freehand Drawing Sheets, Published by Davis & Moughton, Ltd., Birmingham. Price, 12*s.* per set.

(*b.*) Bacon's Soft Grey Line Drawing Charts, coloured; Parts I. to VI. Published by Bacon & Co., Ltd., 127, Strand, London. Price, 7*s.* 6*d.* per set.

(*c.*) M'Dougall's Constructive Drawing Charts. Published by M'Dougall's Educational Co., 24, Warwick-lane, London, E.C. Price, 8*s.* per set.

Schools should possess at least one complete set of (*a*), (*b*), or (*c*).

OBJECT DRAWING AND BRUSH DRAWING.

(1.) Bacon's Common Object Series, 4 sets, 24 cards each; 1*s.* 6*d.* per set. Published by Bacon & Co., Ltd., 127, Strand, London.

(2.) Free-Arm and Blackboard Drawing, First, Second, and Third Series, price 2*s.* 6*d.* each. Published by M'Dougall's Educational Company, Ltd., 1 and 2, St. James's-square, Edinburgh.

(3.) Brush Drawing and Design, First, Second, and Third Series, price 5*s.* each. Published by M'Dougall's Educational Company, Ltd., 1 and 2, St. James's-square, Edinburgh.

DESIGN.

A selection from the following will be found useful:—

(1.) Geometrical Design, by J. Petty. Price, 2*s.* Published by E. J. Arnold & Son, Ltd., Leeds.

(2.) The New Art Geometry, by Steeley and Trotman. Price, 2*s.* Published by Bacon & Co., Ltd., 127, Strand, London, W.C.

(3.) Elementary Drawing and Design, by E. R. Taylor. Published by Macmillan & Co. Price, 2*s.* 6*d.*

(4.) The A.B.C. of Drawing, by F. G. Jackson. Published by Chapman & Hall. Two parts. Price, 2*s.* 6*d.* each.

(5.) The A.B.C. of Design, by F. G. Jackson. Published by Chapman & Hall. Two parts. Price, 2*s.* 6*d.* each.

(6.) Dawson's Elementary Design. Published by Chapman & Hall. Price, 3*s.*

BOOKS.

Many good books on Design, Art Teaching, Principles of Ornament, &c., are published by the following firms, viz.:— Messrs. Chapman & Hall, 11 Henrietta-street, Covent Garden, London, W.C.; Messrs. B. T. Batsford & Co., 94, High Holborn, London, W.C.; Messrs Blackie & Son, Ltd., 50, Old Bailey, London, E.C.; from which firms catalogues can be obtained. Most of the books and models mentioned below can be had from the usual educational supply firms in Dublin, Belfast, and Cork.

Among the most useful books for Secondary Schools are the following:—

Elementary Art Teaching, by E. R. Taylor.
How to Teach Drawing in Elementary Schools, by T. R. Ablett.
Lessons on Decorative Design, by F. G. Jackson.
The Rudiments of Design, based on Plant Form, by H. T. Wyse.
Japanese Encyclopædia of Design, Book II.
Alphabets, Old and New, by L. F. Day.
Moody's Lectures and Lessons on Art.
Glaisher's Outline's of Historic Styles of Ornament.
Progressive Design for Art Students by James Ward.
Plant Drawing and Design, by Lilley and Midgley.
Modelling—A guide for Teachers and Students, by Prof. Lanteri. Two volumes.

MODELS.

For the third and fourth years' Drawing courses a complete set of Geometrical Models, which can be had from Chapman & Hall, or educational supply firms in Dublin, Belfast, or Cork, will be required, also a good selection of Casts.

The set of Models should include the following:—

Cone; base, 10 inches diameter; axis, or altitude, 15 inches.

Ring; outside diameter, 12 inches; section, 1½ inches by 1½ inches.

Square prism; edge of base, 7½ inches; length or altitude, 15 inches.

White unglazed long-necked bottle; height, 12¾ inches; greatest width, 6½ inches.

Cylinder; base, 8 inches diameter; length or altitude, 12 inches.

Large Solid Cube; edge, 10 inches.

Large unglazed terra-cotta Vase; height, 9½ inches; greatest width, 8¼ inches.

Hexagonal Prism; edge of base, 4½ inches; length or altitude, 15 inches.

Triangular Prism; edge of base, 8 inches; length of altitude, 15 inches.

Square Pyramid; edge of base, 10 inches; altitude, 14 inches.

Sphere; 9½ inches diameter.

Skeleton Cube; outside edge, 12 inches; section of frame-work, 1¾ inches by 1¾ inches.

Red glazed Vase; height, 10¼ inches; greatest width, 7 inches.

Small solid Cube; edge, 6 inches.

Wooden imitations of the bottle and vases should be scrupulously avoided.

CASTS.

Suitable Casts can be had from the following firms, viz.:—Brucciani & Co., 254, Goswell-road, London, E.C.; Chapman & Hall, Ltd., 11, Henrietta-street, Covent Garden, London, W.C. (The latter firm publishes a catalogue with about 500 photographic illustrations of casts, including casts of details from nature, by L. Guintini. Price, 2*s*. net. A copy of this catalogue will be forwarded on application free to educational authorities.)

Casts of details from Nature, *i.e.*, hands, feet, &c., can be had from Lorenzo Guintini, 47, Rotherwood-road, Putney, London, S.W.

The following list of Casts will serve as a guide to the kind which might be used for the different classes of work set out in the Department's Programme.

CASTS FOR OUTLINE DRAWING.

From Brucciani & Co. (The numbers are those in Catalogue.)

			s.	*d.*
No.	6	Panel 2 Tomb of St. Antonio, Padua,	3	0
,,	8	,, 4 ,, ,, ,,	3	0
,,	10	,, 6 ,, ,, ,,	3	0
,,	13	,, 9 ,, ,, ,,	3	0
,,	14	,, 10 ,, ,, ,,	3	0
,,	15	,, 11 ,, ,, ,,	3	0
,,	16	,, 12 ,, ,, ,,	3	0
,,	17	,, 13 ,, ,, ,,	3	0
,,	209	Monumental Tablet (1851, 437),	7	6
,,	2,480	Four Caps, Louis XII. Pilasters, 2*s*. each—the set, . .	8	0
,,	2,315	Ten Elementary Studies of Ornament (separate, 2*s*. 6*d* each)—the set,	20	0

From Messrs. Chapman & Hall. (Numbers given are those in the Catalogue.) 46, 47, 54, 70, 71, 72, 73, and others of similar relief.

CASTS FOR SHADING AND MODELLING.

From Brucciani & Co.

		s.	*d.*
485.	Moulding Boss, from St. Stephen's, Westminster,	4	0
1,540.	Centre Rosette, from Trajan Scroll, . .	7	6
1,639.	A. Portion of Spandril, from Stonechurch, Kent,	6	0
1,639.	B. ,, ,, ,, ,, ,,	6	0
2,670.	Egg and Tongue Moulding, . . .	4	0
2,754.	Piece of Gothic Foliage, ...	5	0

	s.	d.
344. Rosette, from the Capitol,	4	0
345. ,, ,, ,,	4	0
2,248. Left Eye of David, by Michael Angelo,	2	6
2,249. Right Eye ,, ,, ,,	2	6
2,249. A. Left Ear ,, ,,	2	6
2,249. B. Right Ear ,, ,,	2	6
2,250. Mouth ,, ,, ,,	2	6
2,250. A. Nose ,, ,, ,,	2	6
2,891. St. John, by Donatello,	5	0

From Chapman & Hall.

No. 56, 3*s.*; 75, 2*s.* 6*d.*; 78, 1*s.*; 389 to 402, 4*s.* 6*d.* each; 465, 2*s.*; 463, 2*s.*

From M. Lucchesi, 36, Charles-street, Hatton Garden,
London, W.C.

Set of Twelve Animals' Heads, ... £1 5 0

The following will be found valuable by Schools taking Modelling:—

From Chapman & Hall.

	s.	d.
Cast of a Bust, First and Second Stages,	8	0 each, net.
,, ,, complete	6	6 net.
,, Foot, First and Second Stages,	4	6 each, net.
,, ,, complete,	4	6 net.

(10 & 11.)—DOMESTIC ECONOMY.

INTRODUCTION.

Instruction in Domestic Economy has come to be regarded as an essential feature of a girl's education. The formation of public opinion in this respect and its growth to the conclusion stated has been due to an increasing liberality in educational views; to the perceptible increasing complexity of the operations involved in the management of a home, with its ever widening circle of relationship to the individual, to society, and to the national standard of health and comfort; to a desire, itself the outcome of a rising standard of general education, to become skilled in the domestic arts, and to obtain some insight into the principles and processes involved; and to the deepening conviction that the application to the activities of a home of the facts of her own experience, or of those of her family, is insufficient to enable a woman to cope successfully with the many-sided demands made on one entrusted with the care and supervision of the young, with the spending of a family income, and with duties involving a knowledge of accounts, rates, taxes, insurance, principles of sanitation, and management of servants.

The subject is eminently a practical one. So true is this that many still contend that the home is the only possible training school. No doubt the home must be the central fact, and home influence and experience dominating factors in the instruction; but it must be remembered that the subject-matter of Domestic Economy forms most valuable material for the general education of girls, and that to treat it with sufficient importance requires opportunity and organization, such as the home cannot provide. Further, it should not be overlooked that intelligent interest, a sense of the dignity of domestic work, and a conviction that the home provides full play for intellectual capacity—necessary conditions of successful management—can be developed through a study of the collective wisdom of the best house managers and a critical examination of their methods, recipes, and practice in the light of the teachings of modern science; and that such treatment of the subject is possible in the majority of cases only through co-operation and centralisation of efforts, *i.e.*, in the school.

It is possible that the majority of Secondary School girls may never be called on habitually to perform the ordinary duties of a household, nevertheless they cannot hope to become good managers without knowing how household work is done, and without being capable, if necessary, of doing it. Moreover, as has already been indicated, ability, however great, to perform the daily routine duties of a household does not form the complete equipment of a good manager. Such an one should understand the function, cost, and economic preparation of food; the function, cost, and making and repairing of clothes; the keeping of accounts; the percentage of income that should be allocated to each head of expense, including provision for the future; the selection, lighting, warming, ventilation, and sanitation of houses; the laws of health; sickness and nursing—in a word, she must understand how to spend a family income to the best advantage, and she must be capable of applying this knowledge to the special circumstances of the household for which she is responsible.

With such ends in view, the practice-lessons suggested in the following syllabuses should not be of a mechanical character, *i.e.* repetitions of exercises until the pupils must needs do them, as taught. The instruction should aim rather at bringing home to the minds of the pupils, by critical discussion of the facts of experience and by experiment, a good understanding of underlying principles, *and at providing sufficient practice to illustrate these principles fully.*

The subject, as treated in the Special Course, should be introduced into the school curriculum during the last two or three years of school life, but the Auxiliary Course may be taken up much earlier. The teaching should be based on the previous, and possibly concurrent, studies in Experimental Science, utilising the facts and applying the *methods* of those lessons, and displacing the vague quantities, approximate measurements, and empirical knowledge of the average housekeeper by the exact quantities and measurements, and by the reasoned experience to which the pupil has now become accustomed. Further, the closest relationship should exist between the school work in Domestic Economy and in such other subjects as Arithmetic, Drawing, and English.

It will thus be seen that the subject, as proposed to be treated, is a wide one, one on which much of the previous teaching may be brought to bear, and one which may be largely used to show (which is by no means too clear) that school studies do have some relation to the outer world, and do form some preparation for right living.

Hygiene and Economy.

As a rule the Hygiene and Economy may be taught by lecture and demonstration in the class-room. The practice lessons, and experiments, must however be worked through *by the* *pupils themselves* in the kitchen, the sewing-room, or the laboratory. At practice, pupils should work in pairs: not in groups of three or four.

The concurrent study of Physiology would be a great help to the teaching of Domestic Economy on the lines suggested in this syllabus; and in those schools which do not take up the separate study of Physiology and Hygiene, the simpler facts of those Sciences will require some attention in the first year of the Special Course in Domestic Economy.

That part of the syllabus which deals with the composition of foods and with their nutritive values cannot be too clearly dealt with, for the domestic and social evils arising mainly from insufficient nourishment are too common to call for comment. The dangers of injudicious choice of foods should also be clearly brought out.

The greatest stress, however, is laid on those parts of the syllabus which deal with household accounts and expenditure; and the normal grant will be recommended only for those schools in which that part of the work is thoroughly well done.

For the lessons that come under the head of Practice in cookery and cleaning, a list is given showing how the different operations may be combined with demonstration cookery and cleaning.

Practice.

It must not be overlooked, however, that demonstration should occupy but a subordinate place in these practice lessons; and further, that it should be confined to what the pupils cannot be reasonably expected to think out for themselves, and that so far from superseding, should rather aim at developing the initiative of the pupils. At a practice lesson *every* pupil should have enough work to occupy her for the full period of the lesson. The demonstration of a new process is not always to be given at the beginning of a lesson, but should come in at the appropriate time. It is also well to vary the method, and, occasionally, instead of giving a general demonstration, to let the pupils try a certain process for themselves, and to show those that fail to what failure is due. Demonstration should aim at guiding the class rather than at leading it.

It is in these practice lessons that not only the art of cooking and cleaning may be mastered, but also (under a good teacher) that the true spirit of economy—thrift and management—can be developed.

The pupils should have large aprons (studio pattern); the hair should be kept tidy; and nothing slovenly should be allowed.

Not alone should the price of each dish be given, but the *menu* should, if possible, be arranged for a small number of persons; and, if the girls dine at the school, the art of serving food can be easily taught.

Simplicity of dishes, smallness of price, and a certain cost per head should be always aimed at.

Under a skilful teacher, a number of indefinable good qualities can be cultivated: the kitchen should be made a ground for developing a girl's neatness and taste, and not converted into a place where she looses these qualities.

NOTE.—*Managers of Girls' Schools are advised to take up the study of Domestic Economy along with that of Physiology and Hygiene. The teacher should read over the separate syllabus of that subject.*

SPECIAL COURSE.—THIRD YEAR SYLLABUS.

HYGIENE.

1. *Description of human body*, aided by charts; division based on simple experience; bones, muscles, nerves, blood, skin. Lessons purely introductory, and confined to physical differences.

2. *Composition of body.*—Evidence of loss; hand on polished surface; breath in cold air; water. Breathing into lime water; result. Presence of nitrogen shown in characteristic smell of burning hair, bones

3. *Fact of waste repaired and growth sustained.*—Examination of ordinary food stuffs. Salt and water in most foods. Potatoes scraped, starch strained off, dried and tested for carbon. Heated, it chars (test for carbon). Albumen. Dried white of egg mixed with soda-lime, and tested for nitrogen.

4. *Chemistry of Food.*—See Special Course in Physiology and Hygiene.

5. *Water.*—Water as a solvent; rain water and spring and river water; drinking water; physical properties of good drinking water; taste of boiled water; sediment in boiling utensils; hardness of water; other inorganic matter in water; danger of leaden pipes for water. Organic matter in water; bacteria in water; microscopic examination of stagnant water; test for organic infected water. Filters; conditions of reliability of filters.

6. *Digestion.*—Its object. A general outlined description of the digestive organs, and their work, by means of diagrams. Importance of mastication. Action of saliva may be taken as an evidence of chemical changes which take place. Experiment as in syllabus of Physiology.

7. *Circulation of Blood.*—Description of course of blood; the heart, arteries and veins. Change of blood during circulation. Its work.

8. *Respiration.*—Fact of respiration noted; description of lungs, and demonstration and mechanism of breathing illustrated by means of diagrams on lungs and windpipe of sheep or rabbit. Advice on proper breathing. Harmfulness of any clothing which prevents full expansion of lungs.

9. *Air.*—Composition of air; carbonic acid; respiration of plants and animals; combustion; noxious gases; escape of gas for lighting; excess or defect of water-vapour. Dust; particles of solids; microbes; description of microbes; their *rôle*; conditions which favour their growth. Ventilation; principle of heated air rising; experiments; natural and artificial. Ventilation incomplete without two openings; good ventilation and draughts; natural ventilating shaft in houses; space required in dwelling houses. Demonstration on simple ventilators. Diagrams, illustrations.

10. *Heating.*—Temperature of body and outer air; necessity of heating; phenomena of combustion; effects and products; what draught in fire means; condition of good draught; heating by open fires and stoves; advantages and disadvantages; the kitchen range; dampers or regulators in stoves. Gas fires; oil stoves; their hygienic value.

11. *Skin.*—Description; sweat glands; sebaceous glands, their functions; necessity for washing skin; soap. Baths and bathing; warm, tepid, and cold bath; suitability of each kind. Evaporation from skin; loss of heat; damp clothes; secondary aids for regulating

heat of body; how they favour action of skin; good conductors, bad absorbents; danger of chill; good absorbents, bad conductors; their value for sick, young, and old. Examination of linen, cotton, and woollen underwear; non-conductors, waterproofs, rubber-shoes. How material, texture, form, and colour can alter hygienic value of clothing. The ideal dress.

12. *Lighting.*—Description of eye; a good light for the eyes; restful colours. Natural light; effect of sun as oxygen-producer in plants; its disinfecting power. Comparison of candle, lamp, and gas light as regards brilliancy and steadiness. Effect of lighting on chemical composition of air in room. Differences of oil, gas, and electricity in this respect. Necessity of ventilation.

COOKERY.

Economy.

A consideration of a diet of uncooked food will at once show the advantages of cooking in regard to mastication, to ability to mix foods, to appetite, and to economy of hot food for body. Cooking—the application of heat to food; bread, too near fire, burns; egg, in lukewarm water, never cooks; hence, proper temperature and time: different modes of cooking; advantage of cooking for mastication; cooked and uncooked meat; white of egg coagulates on boiling; bullock's blood also hardens with heat; raw white of eggs soluble in cold water; raw fresh blood mixes with water.

1. *Boiling.*—By putting into (*a*) cold water, and (*b*) boiling water; result. Hard water and soft water in cooking. Slow and fast boiling. Experiment of pudding mixture placed in cold water or boiling water (*a*) in clean cloth, (*b*) floured cloth. Dissolve raw white of egg well beaten up in water, boil and scum. Test scum dried. Soak little juicy meat in cold water, boil, scum, test scum dried. Reason of scumming. Bone treated with hydrochloric acid, boiled; or ordinary bones boiled and cooled. Gelatine; its use. Economic advantage of boiling; weigh meat before and after boiling. Temperature for fish. Concentrated acetic acid poured on white of egg; result. Eggs poached in water and vinegar. Fish rubbed with lemon. Action of salt on raw beef. Piece of meat let stand with salt. Boiling-point of salt water.

2. *Stewing.*—Its principle; aim, temperature, economy. Bain-marie (ordinary stone jar in pot of boiling water): Principle, use, economic advantage.

3. *Frying.*—Temperature of fat compared with water. Bread fried in warm fat, in hot fat. Temperature of frying fat. Use of the thermometer and practical tests for testing temperature of fat. Egg and bread crumb in frying. Water (very little) dropped into hot fat; result. Flouring fish, &c., for frying; and economic advantage of frying.

4. *Roasting.*—Heating by direct radiation; kind of fire needed; advantages and disadvantages from economic point. Temperature; effect of slow fire and quick fire on raw meat.

5. *Baking.*—Hot air chamber; effect on food; advantages and disadvantages of non-escape of air. Ventilation of ovens. Principle of double baking pan. Slow fire and quick fire in baking; economic advantage. Baking powder: its composition. Separation of starch from gluten in wheat. Gluten: its properties in bread making. Cake made of rice flour or corn flour alone. Right heat of oven.

Effect of too great or too small heat. Yeast in bread-making. Examine by microscope; proper heat for fermentation; heavy bread or cake; light bread. Value of beating white of eggs; of mixing butter and flour thoroughly; of kneading yeast bread; of not kneading ordinary paste for tarts.

6. *Grilling* meat over a slow fire or quick fire; economic advantage.

Food Values.

Consideration of foods cooked may follow practical lesson, or hints may be given during lesson. Appearances of good foods can be studied in presence of objects. The advantages of separate treatment of each kind. Explanation of differences of time of cooking in beef, mutton, veal, pork, &c.

(1.) Nutritive properties of meats. General remarks. Mode of cutting up meat may be studied from chart of butcher's "joints." Each piece of meat cooked should be pointed out on chart.

(2.) Eggs.—Weight of good eggs; test in salt water; action of butter rubbed on fresh eggs.

(3.) Milk.—Constituents; action of boiling on milk; sterilizing.

(4.) Peas, beans, and lentils. Their mode of preparation and value as foods.

(5.) Potatoes.—Slice of potato ¼-inch thick held between pupil and light; distribution of water and starch; good potatoes; danger of new potatoes; water changed on boiling. Storing of potatoes.

(6.) Cereals.—Value of ordinary kinds.

(7.) Green and fresh vegetables. The vegetable which appears in *menu* should be considered as regards proper preparation and dietetic value.

Practice.

The following scheme of lessons is intended to illustrate how by choosing seasonable food the different operations of plain cookery may be practised in the first year. The operations of boiling and stewing are intended to be fairly mastered before a new process is introduced. The thermometer should be constantly used to show the differences of temperature required for different methods of cooking the same kind of food, and for the same methods of cooking different kinds of food.

Demonstration is necessary at the beginning of the course; and practice in every new process should be preceded by a short demonstration. Attention is again drawn to the fact, however, that although demonstration is often an essential part of a practice lesson, demonstration is not practice. Demonstrations must be kept within proper limits, and every pupil should have her full practice lesson every kitchen day. Demonstrations in cleaning may be given at a time when the cooking is not pressing. Practice in cleaning is always possible.

A complete and inexpensive *menu*, made up of seasonable and cheap foods, should, if possible, be worked through at every lesson, for, although the attention of the pupils is centred on the mere operation, still in this way they become accustomed to combined foods with a view to their completeness as life supporters, *and to the cost of a* menu *for a given number of persons*. Dishes should be plain.

The cost of materials of every dish, and of every *menu*, should be considered; and the teacher must constantly call attention to the economic value of the various dishes.

The food which is to be cooked should be examined and the qualities of good food discussed; the advantages of cooking the particular food in the way it is being done are to be made clear.

A chart of animals which supply butcher's meat should be hung in the class-room, and parts of meat pointed out.

Notebooks should be kept by pupils, and should be corrected regularly by the teacher.

SCHEME OF COOKERY AND CLEANING.

First Term: October—December.

1. Lighting kitchen range.
Boiled and poached eggs.
Meat boiled by placing in cold water (stock).
Bones boiled.
Coagulation of white of egg by heat and loss of flavour in meat must be noted. Liquid from bones cooled and examined.
Plate cleaned and Pots washed and dried.

2. Potage: made with meat or bones.
White sauce for mutton.
Boiled potatoes.
Boiled mutton.
Explanation and results of different methods of boiling noted.
Washing knives, spoons, &c.

3. Onion soup.
Boiled bacon.
Boiled cabbage.
Steamed potatoes.
Sweeping of kitchen; replacing brushes, &c.

4. Celery soup.
Stewed beefsteak.
Stewed potatoes; spinach.
Boiled pudding.
Dusting.

5. Pea soup.
Boiled fish.
Mashed potatoes.
Boiled rice and prunes.
Scrubbing of tables in white wood.

6. Julienne soup
Hashed mutton or beef heated *à bain marie.*
Potatoes mashed and baked.
Stewed turnips or onions.
Custard heated *à bain marie.*
Cleaning of painted wood; cleaning of varnished wood.

Second Term: January—Easter.

1. Carrot soup.
Fried beefsteak.
Fried potatoes (chips).
Brussels sprouts.
Stewed apples.
Fat clarified—Cleaning of glasses, decanters, bottles,

2. Haricot soup.
   Fried fish.
   Croquettes of potatoes
   Omelet.
   Cleaning silver plate.
3. Red cabbage soup.
   Roast mutton.
   Haricot beans.
   Potatoes boiled and fried.
   Pancakes.
   Cleaning knives, forks, &c.
4. Turnip soup.
   Roast pork.
   Apple sauce.
   Red cabbage.
   Cleaning zinc.
5. Green soup.
   Baked fish.
   Potatoes with parsley sauce.
   Blanc mange.
   Cleaning copper.
6. Leek soup.
   Roast beef.
   Roast potatoes.
   Baked milk pudding.
   Cleaning tins.

Third Term: Easter—Midsummer.

1. Rice soup.
   Grilled chops, roast potatoes.
   Salad.
   Mayonnaise sauce.
   Cake—made with baking powder.
2. Spring soup.
   Roast lamb.
   Mint sauce.
   Potato pie.
3. Cabbage soup.
   Veal cutlets or roast veal.
   Salad.
   Roast potatoes.
   Madeira cake.
4. White soup.
   Boiled fowl.
   Boiled potatoes.
   Cauliflower.
   Tart made with short crust
5. Green soup.
   Grilled fish.
   Roast potatoes.
   Asparagus.
   Boiled jam roll

6. Lentil soup.
   Fish croquettes.
   Potatoes with herbs.
   Mould of vanilla cream.

HOUSEHOLD KNOWLEDGE.

Cleaning and Care of Utensils, &c.

1. Principle stains on kitchen utensils; grease, insoluble in water Soap; heat small pieces of mutton suet in solution of caustic potash in test tube, *heat to boiling-point*, add salt, examine result. Soda ammonia, and chalk. Soluble and insoluble soaps.

2. *Rust.*—Its prevention; galvanised iron.

3. Action of acids on zinc and copper and brass; dangers of these metals; use of vinegar in cleaning. Stains on silver; stain from eggs, how removed. Mechanical action in cleaning, of whiting, emery powder, sand-paper, sand, and of cinders. Cleaning of knives. Danger of cleaning bottles with shot. Black-lead and turpentine: their action in cleaning range.

4. Consideration of action of different metals under heat, lead, tin, iron, &c., will give at once hints as to their advantage in the kitchen, as well as to the care to be expended on them.

5. Kinds of brushes and cloths that should be used; their care.

Heating.

Heating by convection and radiation; loss in ordinary chimneys; economic and wasteful grate. Description of different kitchen ranges; how they are set and cleaned. Meaning of slacking a fire, and how it is done. Different fuels; economy of fuel; the coal that is most economical.

Practice how to light and keep down a fire.

Clothing.

1. *Choice and selection of clothes*; good taste in clothing; fitness, colour, and fashion. Linen and cotton examined under microscope; treated with drop of oil (olive); result noted. Economic value of linen and cotton; comparative facility of removing stains Wool and silk compared. Shoddy; cheapness and durability. Economic colours; economic form of clothes, and best wearing textures.

2. *Care of clothes*: underclothing, linen not drawn together before washing, is torn. Outer clothes; brushing; removal of mud and grease stains. Solvent power of ammonia, turpentine, benzine, naphtha, and alcohol. Reason for rubbing stain with flannel, and reason of absorbent being under stain where rubbed. *Practise* removing stains from clothes.

3. Advantages and disadvantages of a small quantity, or of a large quantity, of linen and clothes.

Lighting

Lighting: most economical light, sunlight. Care of candles; candlesticks. Oil lamps; paraffin; dangers of impure paraffin. A good lamp; devices for complete combustion; glass, burner, air chamber, &c. "Lampe belge," two air currents. Inexplosive lamp.

Practise how to clean and light a lamp.

NEEDLEWORK.

I.—*Sewing.*

1. Plain sewing.—A demonstration lesson by means of chart or other approved apparatus for teaching sewing. Such method may seem unnecessary with girls of this age, but chart is used merely to help explanation, which should last only a few minutes. Pupils can then work independently under direction of teacher.

2. Samples of stitches:—(1.) All operations of plain sewing, as hemming, felling, running, &c. (2.) Two patches. (3.) Buttonholes, buttons. Samples should be one foot wide, one yard long. Stitches should be done on width. Calico or linen undressed and not too fine.

3. Darning on coarse linen or woollen stuff.

4. Lesson in use of sewing-machine should be given early in term, and all pupils at end of term should know how to fill bobbin, shuttle, and needle, and regulate size of stitches.

II.—*Measuring and Pattern Drawing.*

The system of pattern drawing employed should be one that depends on the ruler, tape-measure and chalk alone. The pattern should be drawn by the teacher full size on board, and simultaneously by pupils, full size on pattern paper. Patterns cut out in paper and material. Patterns reduced to scale in exercise books, and explanation of figures written out on opposite page by pupils.

The following patterns should be worked in class:—Two patterns chemise; two patterns knickers. Pattern ordinary blouse and sleeve for same.

NOTE.—In drawing patterns for dresses, it is well at first to take measurements from the bust, and to use the bust as object during lesson.

III.—*Making.*

1. One garment at least hand-sewn. "Plain" means worked with ordinary plain stitches and not fancy lingerie ones. Articles can be simply trimmed, if desired.

2. Blouse without lining; machine can be used for certain parts, but parts best done by hand should be hand-sewn, as *e.g.*, shoulders closed, sleeves put in, casings, &c.

NOTE.—Pupils of class need not all work one design; variety should be aimed at. Taste as well as economy should be displayed. The pupils' sense of colour and harmony is thus developed, and a knowledge of how design may be varied is gained.

3. *Cost.*—List of materials used; their lengths or quantity, and prices, should form necessary part of work.

SPECIAL COURSE.—FOURTH YEAR SYLLABUS.

As observed in the introduction, this subject is eminently a practical one. A certain number of scientific facts or principles must be known, but Domestic Science proper is the deductive application of these to particular instances. For this reason the Science, so far as it concerns Hygiene or Economy, must deal with incidents which are already familiar to the pupils, or which they are likely to meet with. The observation and experience of the class must constantly be made use of. The circumstances of the

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pupils must be attended to, and the syllabus should be used with the utmost flexibility. Thus, the general principles of feeding, housing and draining are always the same, but they would not be exemplified in exactly the same way in town and country.

This second part, which deals principally with the choosing of food and houses, and with some notions of illness, must take account of many circumstances that are purely local, while household accounts and management of incomes must deal with incomes suitable to circumstances of the pupils.

In practice a complete *menu* should be aimed at as before. Cleaning of different woods, bronzes, etc., might be added.

Drawing should be combined with the needlework. It will serve to increase the interest of the pupils in their work, and at the same time give them a better taste for arrangement.

PHYSIOLOGY AND HYGIENE.

FOODS.—1. Their nutritive qualities. Necessary food stuffs—proteids, carbohydrates, fats, salts, and water. Accessories: condiments and stimulants.

2. Loss from body daily of carbon and nitrogen gives proportion in which these two elements should be taken. Proportion of carbon and nitrogen in proteid. Mixture of proteids and carbons. What is a complete food? Milk as complete food for infants; subsistence diet of adults, of labourer, of growing boys and girls. Result of a diet containing too little nitrogen, carbon, fat, salts, or fresh vegetables. Results of a too great proportion of these elements. Economic value of potato diet, oatmeal, bread, and tea. Table of principal foodstuffs, in amounts of proteids, carbohydrates, and fats. Problems worked out to show justification or reverse of ordinary practice of combining macaroni and cheese, bacon and eggs, pork and beans, eggs and rice, and serving combined bacon and fowl, roast beef and Yorkshire pudding, etc.

3. Problems worked out to show in what proportion one ought to combine two or more foods in order to have a complete food.

4. Values of meat soup and vegetable soups, of brown and white breads.

5. Tea, coffee, and cocoa; their value as food accessories. Value of chicory. Difference between a decoction and an infusion.

ALCOHOL.—What it is. Popular fallacies as to its power. Its coagulation of albumen. Effect on nervous system. Effects of abuse of alcohol on individual as regards health, intelligence, and will power. Effects on individual's family.

DIGESTION.—Work of digestion might be given experimentally, as suggested in the Special Course in Physiology and Hygiene (Section II., 2).

For a proper description of the organs of digestion a good chart or model is necessary; the separate organs of some animal, for example a sheep, should, if possible, be shown to the class.

DIGESTIBILITY.—1. Comparative digestibility of foods pointed out in first year.

2. Good nourishment does not consist in what is eaten, but in what is assimilated.

3. Things which alter digestive value of food. Time and regularity of meals Over eating or too long intervals without food,

Badly cooked, badly served, badly seasoned, or badly varied foods. Badly masticated food. Too much or too little fluid. Evil effects of latter.

4. Consideration of the arrangement of the dinner. Value of soup or broth at beginning of meal. Arrangement of courses. Consideration of general practice of serving pork and apple sauce, boiled mutton and caper sauce, etc. Comparative values of tea and coffee as after dinner beverages.

5. Effect of nervous system on digestion: instance effects of fright or worry. Necessity for good humour and relaxation at meal-time.

6. Effect of exercise on digestion: when exercise is especially necessary. Difference in diet of sedentary people and those who have active exercise.

7. Number of meals, and of what each should comparatively consist.

EXERCISE.—1. Growth of muscle by exercise, increase of respiration, effect on circulation, increase of perspiration, how it affects digestion—instance hunger. Excess of movement—fatigue, strain.

2. Lack of exercise; its effects among healthy well-nourished persons.

3. Rest; change of occupation. Sleep: Hygienic and economic advantages of sleeping at night; how bathing feet in hot water helps sleep. Position of sleeper's head. Amount of sleep necessary for children and others.

COOKERY.

Economy.

FOOD.—Appearance of good meat, flour, potatoes, etc., already known. Time to buy food; when a food is said to be in season; where to keep food, and in what kind of vessels. Ways of preserving food, as (1) exclusion of air, impervious layer, meat dipped for five minutes in boiling water, chops turned on the pan, meat covered with layer of fat; (2) exclusion of germs; meat cut in pieces, heated in vessel, and mouth closed with clean cotton wool; (3) preservatives; salt, sugar, borax, powdered charcoal; and (4) pickling in vinegar, etc.; (5) drying fish and meat, fruit and vegetables; (6) freezing.

MARKETING.—Value of fresh and preserved foods. Tinned meats, etc., condensed milk.

ADULTERATION OF FOOD.—1. What it is. Ordinary adulteration of different foods. Practical tests.

2. Milk.—Its density; amount of cream. The lactometer.

3. Butter.—Iodine, reaction of starch. Melt in tall narrow glass, let cool, water sinks. Butter dissolves easily and quickly in ether; other fats with more difficulty.

4. Lard.—Water test; should be free from water.

5. Eggs.—To know if eggs are fresh, (a) 2 oz. salt in pint of water to see if eggs float; (b) by looking through egg; good egg, clear in middle; bad egg, clear at ends.

6. Wheaten Flour.—Foreign starches seen by microscope. Shake flour with chloroform, flour floats mineral matters sink.

7. Bread.—The properties of good bread. Difference in bread made with sour milk, baking powder yeast, or ærated. White,

household, and brown breads. Tests for presence of alum or of sulphate of copper in bread.

8. Arrowroot.—A jelly of arrowroot looks fresh and stiff after two or three days, other starch jellies turn liquid within 24 hours.

9. Tea.—Mixture of other leaves, mineral substances.

10. Coffee.—If chicory is present it sinks in cold water and colours the water.

11. Cocoa.—Thickens on boiling if starch is present.

12. Beer, Wine, etc.—Adulterations; test for.

Note.—A few lessons should be devoted to the feeding of infants and young children, using the following outline as a basis:—

Infants should not be fed artificially, unless it is necessary. Reasons why infants require special food, and why the constituents of their food must be varied at different ages. Dangers of improper food; may be of unsuitable composition, indigestible, or innutritious; may be badly prepared, or stale; may be given in wrong quantities. Construction of feeding bottles; those with tubes should should never be used. Cleansing and care of bottles.

Times of feeding for various ages. Sterilization of milk and other foods; advantages and disadvantages. Suitable dietary in composition and quantity for infants from one to three, three to six, six to nine, and nine to twelve months.

Suitable dietary for children from one to two years.

Diseases of children directly caused by unsuitable food, indigestion and cholera infantum, rickets, scurvy.

Demonstrate the cleaning of feeding bottles and the sterilization of milk.

Practice.

1. The cooking of complete *menus* could be continued in this year and the pupils should now give more attention to the composition of the various dishes and the proper way in which different foods should be combined, in reference to their respective proportions of carbon and nitrogen, their digestibility, &c. The mode of cooking should be well varied in each dinner to show how the cooking of different dishes can be conveniently combined so as to save time. *Menus* should consist of two kinds of meat, or meat and fish, and the price reckoned as before. Several *menus* in which neither fish nor meat appear should be cooked. A few breakfast dishes, as oatmeal, different rissoles, as well as breakfast cakes, should be done. The cooking of food for infants and children might also be given, as well as some invalid cookery.

2. A few lessons on preserving might also find place. Making of bread should also form one at least of the lessons.

3. Invalid Cookery.—Cooling drinks; lemonade, barley water, toast and water, beef-tea, chicken broth, with a knowledge of how they should be flavoured. Gruel, invalid's fish, cutlet. Egg-flip, jelly. One or more of these can be made in addition to the dinner.

4. Preserving: Eggs, salting butter, whole fruit in vinegar and syrup, marmalade, one or two jams, jelly. How to keep apples and pears.

Household Knowledge.

Care of the House.

The teacher might introduce this part of her subject by reference to different types of housekeepers; she will have an opportunity of pointing out in the various types the many qualities which she has already tried to cultivate in her pupils. She might begin by examining the cases of such housekeepers as the mechanical drudge, one who exhibits no taste and no ingenuity, the type that pays all attention to externals, and the like. The class can then be led to formulate their ideals.

1. Qualities of a good housekeeper. The economic values in a housekeeper of such virtues as order, cleanliness, activity, economy, and foresight, as well as good humour and good taste.

2. Simple laws for letting and renting houses. Liability of landlord and tenant for repairs. Time at which roof and outside of house should be respectively repaired, or painted. The cleaning of windows. Cleaning of inside walls, ceilings, and floors.

3. Value of Cellars.—Their ventilation and dryness.

4. Kitchen.—Complete cleaning of kitchen, how it should be done. Position of kitchen in house; value of a wash kitchen.

5. Bedrooms.—A healthy and economic bed—iron bedstead, hair mattress, light and warm coverings. Its position in room. Disadvantages of bed curtains, tapestries, and plants, and too large carpets. Ordinary furniture of bedroom, its care daily and weekly. Advantages of simplicity and good taste in furniture.

6. Dining-room.—Its use, furniture, and care.

7. Drawing-room.—Its use, furniture, and care.

8. The Yard.—When, and how, to clean it.

9. Drains and water closets: how to disinfect and deodorise.

10. Arrangement of work in ordinary house, according to size. Daily and weekly. The class ought to work this time-table out under direction of teachers.

11. Servants.—Qualities to be looked for in a servant. Hiring them. How they are to be trained. Their material welfare. Relations that should exist between mistress and servant. Dismissing servants. Giving them recommendations.

NOTE.—In connection with the lessons given under this division, practice lessons in cleaning should be arranged. If the actual objects which form the furniture of a house are not easily accessible, some of the materials which compose them should be at hand, *e.g.*, polished wood mirror, gilded frames, bronzes, marble, &c. Practice in cleaning.

Household Accounts and Expenditure.

1. Necessity of separating household and business or professional accounts.

2. Books.—(1.) Daily book with two columns—one expenses paid, other amounts received. (2.) Weekly or monthly division of items under separate heads. (3.) Tradesmen's pass-books. Advantages and disadvantages of credit and ready money. These accounts should be, as far as possible, real; if the expenses of Economy class are entered at every class, they can be afterwards grouped. A little perseverance is required with the work in class.

3. Disposal of one's income. Arrangement and percentage of each head of expenses.

At this stage an attempt should be made to drive home some guiding directions which have become proverbial, such as saving is earning, hence this subject, *i.e.*, Domestic Economy, is of high industrial value; pay ready money; never anticipate uncertain profits; keep the strictest account of all you save and all you spend; see that nothing is lost.

4. What saving is; how and why one ought to save. Economic value of co-operation, savings banks, insurances, and annuities.

Actual account of working expenses as far as coal, light, food used in kitchen, &c., should be kept by pupils and grouped at end of every month.

Washing. Necessity of washing. Try to remove stains of grease from napkin by brushing, shaking, &c. Now try alcohol. Need of solvent. Our ordinary solvent.

NOTE.—In this connection pupils should work out in the laboratory some simple experiments, as soap-making, the bleaching power of chlorine, &c.

(1.) Water: hard and soft water; value of rain water; ways of softening hard water.

(2.) Soap: experiment already given.

(3.) Soda: Its properties; solvent powers in cold and hot water; soda in cold water (undissolved); let rest on linen; result. Effect on animal substances—wool and silk.

(4.) Potash: how used in laundry.

(5.) Ammonia: its action on grease; power of saponification.

(6.) Blue: (1) Indigo blue; (2) Prussian blue.

(7.) Chloride of Lime, or Bleaching Powder.—Bleaching action of chlorine can be shown, if not already done in laboratory.

Presence of chlorine demonstrated by treating bleaching powder with dilute sulphuric acid.

(8.) Starch: its composition and effect on linen; effect of heat on it.

(9.) Borax: its use in the laundry.

Ways in which clothes are injured by substances employed; advantages of home washing.

Washing operations.

(1.) Sorting: how clothes should be sorted; reason of sorting.

(2.) Steeping: let raw white of egg dry on two napkins, plunge one in boiling water, throw other in cold water, and mark results. Steeping in cold water; advantage of adding soda; how dissolved.

(3.) Soaping: action of soap; use of soft soap.

(4.) Changing clothes for boiler; manner of wringing.

(5.) Boiling: action on grease; precautions in boiling clothes; length of time to boil.

(6.) Taking clothes from boiler; washing: idea of rubbing in helping solution of stain; practical hints on washing hems, edges and corners of clothes, as well as lace, &c.

(7.) Wringing: when it should be light or strong.

(8.) Bleaching.—Experiments: good bleaching ground.

(9.) Washing.

(10.) Rinsing: why in rain water if possible?

(11.) Rinsing: why in pipe water if possible?

(12.) Blueing: why in pipe water if possible? In what order things are blued. Experiment on new and old linen and calico.

(13.) Starching. } Ways in which clothes are injured during
(14.) Drying. } operations. Advantages of home washing.

Washing of coloured materials.

(1.) Action of soda on coloured things; action of boiling and bleaching; uses of salt, vinegar, and ammonia.

(2.) Removal of stains from linen.—Iron-mould, oxide of iron; action of salts of lemon on this; when iron-mould should be removed. Why? Fruit or wine stains; action of gas from burning sulphur on vegetable tissues to be demonstrated.

(3.) Paraffin washing.—What it is; its advantages and disadvantages. Consideration of some washing machines and wringers. Their use and abuse.

Ironing.

Need of damping clothes, use of wax and borax. General rules for ironing.

NOTE.—The order of operations given here may be varied at the discretion of the teacher; practice lessons are not obligatory—there is, consequently, the greater need for good demonstrations.

The house; its necessity.

Sanitation of House. (1.) Site.—Soil, aspect, situation, elevation. (2.) Building.—Foundation-materials, damp-proof course, walls, roof, projecting eaves, and lead gutters. Cellars: their use.

(*Note.*—In a climate such as ours, the chief points to consider are how a building is made damp-proof.)

Place of kitchen and disposition of rooms. Plans should be drawn by class.

(3.) Drainage and disposal of waste.—Drainage of sub-soil before building. The water closet, its water supply; trap; course of soil pipe, and necessity for its ventilation. Sewer gas; rural system of disposal of refuse. Kitchen and washing sinks, gully traps, necessity for flushing with soda and boiling water. Disposal of kitchen rubbish, removal and destruction.

(4.) Water supply of house.—Amount necessary for domestic purposes. Dangers attending use of well water and pipe water. Cisterne; advantage of cistern for rain water.

(5.) Papering, painting, and furnishing house; æsthetic and hygienic values. Danger of newly-built houses. Walls—comparative hygienic values of paint, whitewash, varnished paper, and ordinary paper on walls. Colours of walls. Light and dark colours. Floors: values of tiles and wooden floors; nailed boards; tongued and grooved boards, and parquet floorings; objects of waxing boards. Carpets, linoleums, etc.

(6.) Furniture.—Advisability of nothing that will lessen ventilation or serve as a refuge for dust and microbes. Simplicity best rule. Disposition of furniture as regards light and draughts.

For the proper understanding of many things which arise in the course, of a few lessons should be given on:

1. *Microbes.*—Some developed on gelatine should be shown under microscope. What they are, their medium, their *rôle* in (*a*) infection, (*b*) putrefaction, (*c*) fermentation. Ways of destroying them or preventing their multiplication. How food and water can carry them.

(*a.*) Disease in source or animals from which food was obtained.

(*b.*) Absorption from air; meat putrefies easily in bad air, milk turns sour.

(*c.*) Food kept until bad.

2. *Disease*—What it is. Infectious diseases.—Epidemic and contagious. How disease is propagated from one person to another—by water, food, air, contact, etc.

Precautions.—Preventive, *e.g.*, vaccination; isolation; disinfection. Disinfectant, carbolic acid; antiseptic, boracic acid; deodorizer, quick-lime. Difference between deodorizers and disinfectants. Special precautions to be taken in time of epidemic, cooking all food and boiling water, good nourishment and good air. Sicknursing.—How to make patient's bed; washing patient; remove dust from room; make and keep up fire; how to serve patient's food and give medicines. Disinfection of room, clothes, etc.; disinfect linen by adding two tablespoonfuls "Sanitas," eucalyptus, or carbolic acid to water, and steep overnight.

3. *First Aid.*—As given in the Special Course in Physiology and Hygiene, with the following additions—attack of nerves, bleeding from nose, and first symptoms in children's diseases, as croup, measles, whooping-cough, scarlatina, chicken pox, mumps, and ringworm. Precautions to be taken.

Practice for First Aid and Sick Nursing.

Frictions: artificial respiration; making a mustard plaster; making a poultice; simple bandages and bandaging; way to make an emetic. Class should be shown to make up a simple cupboard for home treatment.

NEEDLEWORK.

I.—*Measuring and Pattern Drawing.*

The pupils at this stage should be able to take measurements easily and quickly.

(1.) Pattern for bodice for adult—two or three side piece and bias darts. Sleeves for same.

(2.) Pattern skirt or underskirt.

Patterns cut out in paper and material.

Note.—The busts must be used as objects during these lessons.

II.—*Making.*

(1.) Bodice lining for adult. Lining only need be finished, but sleeves, bones, hooks and eyes, &c., should be put in.

(2.) Simple skirt or underskirt.

All work should be fitted by pupils themselves after a general demonstration.

III.—*Cost.*

The prices and lengths of materials for garments made should be reckoned as before.

SUGGESTIONS FOR DOMESTIC ECONOMY EQUIPMENT IN DAY SECONDARY SCHOOLS.

Cookery.

As Cookery forms an essential subject of the Domestic Economy course, provision for cooking, in a kitchen or elsewhere, is necessary in all schools adopting the programme. In schools possessing a good kitchen it is desirable that arrangements should be made to utilise it, the instruction to be given at such times as the kitchen can be completely given up for the instruction of the pupils. Such an arrangement will be approved provided there is sufficient accommodation for the number of pupils taught, and for this purpose twenty-five square feet per pupil may be regarded as a minimum.

Washing or Laundry Work.

It must be clearly understood that individual practical work is expected and that demonstration lessons alone are not be regarded as fulfilling this part of the programme. The kitchen may be used for this purpose. For this section of the work some special equipment will in general have to be provided, so that accommodation for at least one half of the pupils in the class may be given. Wooden troughs for washing, 3 feet by 1 foot 6 inches, by 1 foot 2 inches deep, will be found suitable; sufficient table space for ironing and making up is also required.

Home Sewing.

It will, in general, be most convenient to the school authorities and to the pupils that this work should be done in an ordinary classroom, or in the drawing class-room. The usual straight school desks are unsuitable, and unless single desks are available, chairs and tables should be provided. This subject is one in which the arrangements for the physical comfort of the pupils are most important, in regard to position in sitting and to the light available. These matters should receive special attention, and the Department's Inspectors will be instructed to report upon unsuitable conditions, in which case the school grant may be reduced.

Special Composite Domestic Economy Room.

In schools which do not possess a suitable kitchen, or which are unable to give it up completely, as required for the instruction of the pupils, it will be necessary to provide a Domestic Economy room, which should be composite, so that all the instruction required under the Domestic Economy Syllabus may be accomplished in it. Advice and suggested plans for the suitable arrangement of rooms will be given by the Department's Inspectors upon application to the Department. The following equipment is regarded as a minimum in such a room :—

Cooking stove or range,

One sink, at least 2 feet 6 inches by 1 foot 11 inches, by 1 foot deep, with drainage boards,

One cupboard or press for materials,

Dresser or cupboard for utensils,

Cupboard or press for sewing work,

Blackboard,

Shelves with hooks for utensils,

Deal tables, solidly constructed, 2 feet wide and 2 feet 9 inches high, allowing 2 feet of length per pupil.

Such a room should be a model in respect of neatness, and pupils should be thoroughly acquainted with the arrangement of the utensils and materials. A suitable room for a class of sixteen girls would be 600 square feet, *i.e.*, 20 feet wide by 30 feet long, by 13 feet high. A recess for scullery purposes may be provided if accommodation is available. Hats, cloaks, &c., must be provided for outside this room.

The ventilation of such a room will require special attention when cookery is in progress, and the temperature should not be allowed to rise above 70° Fahrenheit. Pupils should themselves be made acquainted with the means of ventilating the room, and should be capable of attending to it without the teacher's instructions.

SUGGESTED LIST OF APPARATUS.

NOTE.—This list is drawn up for eight pupils only—four groups of two. For larger numbers the utensils must be added to.

Fixtures and Furniture :

Cooking stove or range.
Sink, at least 2 feet 6 inches by 1 foot 11 inches, by 1 foot deep, with drainage boards.
Cupboard or press for materials.
Dresser or cupboard for utensils.
Cupboard or press for sewing work.
Blackboard, at least 3 feet 6 inches by 3 feet.
Shelves, with hooks for utensils.
Deal tables, 2 feet wide by 2 feet 9 inches high, allowing 2 feet of length *at least* per pupil.
Coal bucket, fire-irons and shovel, cinder sifter.

Apparatus :

Balance with weights to read to 28 lbs.
Spring balance to read to 14 lbs.
Clock.
Thermometers—2.
Tall glass for testing milk.
Charts for Physiology.
Charts of modes of cutting up beef

Utensils :

One pint, half-pint, and quarter-pint measures.
Two iron, tin-lined, round and oval pots.
Three silicated saucepans.
Enamelled-iron saucepan.
Steamer, tin, for large size saucepan.
Two stewpans.
One gridiron.
Two frying-pans.
One omelet pan.
Pot—strong iron—for frying.
Dripping pan (double).
Kettle.
Stone jar.
Four pie dishes.
Tart pans—two large, six small.
Two cake tins.
Fish kettle or key, fitted for saucepan or small pot.
(Roasting jack and meat screen is hardly necessary.)
Eight iron spoons.
Eight forks.
Carving knife and fork.
Eight wooden spoons.
One skimmer.
One wire basket, for frying.
Wire spoon.
Two boards for chopping.
Two meat and suet choppers.
Two colanders (enamelled iron).

Pestle and mortar, stone.
Bread and nutmeg graters.
One dredger for flour, &c.
Two paste-boards.
Four rolling-pins.
Two paste-cutters.
Two pastry brushes.
Water jug, enamelled iron.
Two washing pans, enamelled iron.
One drainer.
Six dishcloths.
Three basins for pastes, milk, &c.
Bin for flour.
Two egg beaters.
Hair sieve.
One spice box, including pepper-box.
Two salt boxes—fine and coarse salt.
Six tin boxes, to hold about 1 lb. or 2 lbs. flour, sugar, &c.
Tea pot.
Coffee pot.
Corkscrew.
Funnel.
Eight cups and saucers.
Eight small plates; eight large plates.

Utensils, &c., for cleaning.

Two zinc buckets.
Six house-cloths.
Hair sweeping-brush.
Carpet sweeper or broom.
Hand brush; dust pan.
Two scrubbing-brushes.
Feather.
Six dusters.
Two black-lead brushes.
Brush for lamp.
Two boot-brushes.
One clothes brush.
Two skins, chamois.
One sponge.

Needlework:

Bust of girl and adult for every two pupils.
One sewing-machine; two flattening irons.
Large cupboard for work. Special tables with drawers, or lids that can be raised, are useful.
Tapes, rulers, paper, undressed calico for cutting patterns.

Given under our Common Seal this 11th day of April, 1906.

L. S.

Present at Board Meeting when Seal was affixed,

T. J. Bellingham Brady, } *Assistant*
Swift Paine Johnston, } *Commissioners.*

WE, John Campbell, Earl of Aberdeen, Lord Lieutenant-General and General Governor of Ireland, do hereby approve of the foregoing Rules and Schedule.

(Signed) ABERDEEN.

Dated this 17th day of April, 1906.

Intermediate Education Board for Ireland.

NOTICES.

THE RULES AND PROGRAMME FOR 1907.

(Printed by Messrs. Browne & Nolan, Ltd., Nassau Street, Dublin.
Price 3d.; by post, 6d.)

Managers of Schools are requested to make themselves thoroughly acquainted with the Rules and Programme now published, as several important changes have been introduced.

STAMPED FORMS OF NOTICE OF INTENTION TO PRESENT FOR EXAMINATION IN 1907. (Rule 15.)

These Forms can be obtained *only* **from the several Stamp Distributors and Postmasters authorized to sell Inland Revenue Stamps throughout Ireland, and in Dublin from the Licensed Vendors of Stamps;** *they are not procurable at the Office,* **1** *Hume-street.*

Forms will be on Sale in 1907 as follows :—

CLASS A, **FEBRUARY FORMS**—*Price* **2/6** *each form, to be on sale from* **1st** *to 28th February, inclusive, but not after the latter date.*

N.B.—Application for such Forms, however, should be made not later than 23rd February.

CLASS B, **MARCH FORMS**—*Price* **10/-** *each form, to be on sale from* **1st** *to* **31st** *March, inclusive, but not after the latter date.*

N.B.—Application for such forms, however, should be made not later than 26th March.

STAMPED FORMS OF NOTICE OF INTENTION TO PRESENT FOR EXAMINATION IN MUSIC.

Students intending to present themselves for examination in music shall transmit to the Board, in addition to the notice under Rule 15, special notice of such intention in the prescribed form, stamped with an Intermediate Education stamp of 10*s.* 6*d.* to be transmitted to the Board not later than the last day of February. These forms can be obtained *only* from the several Stamp Distributors and Postmasters authorised to sell Inland Revenue Stamps throughout Ireland, and in Dublin from the Licensed Vendors of Stamps ; *they are not procurable at the Office,* 1 *Hume-street.*

PRESCRIBED FORMS OF NOTICE OF INTENTION TO PRESENT A CHOIR OR ORCHESTRA FOR EXAMINATION.

Managers of schools desiring to present a choir or orchestra for examination or for the special competition in Dublin shall give notice of their intention in the prescribed form, and submit the names of the pupils composing such choir or orchestra, with a programme of the music they intend to perform. The prescribed forms, together with a fee of £1 1s. (by Postal, or Post Office Order, or Cheque) for each choir or orchestra (an additional fee of £1 1*s.* will be required for the special competition) and the Statutory Declaration as to age under Rule 78 shall be transmitted to the Board not later than the last day of February. Copies of the prescribed forms may be obtained on application to the Assistant Commissioners, not earlier than 1st February (Rules 76 and 81.)

EVIDENCE OF AGE. (Rule 18.)

Evidence of age should accompany the Notice in the case of every student who presents for examination for the first time.

Such evidence of age should be securely attached to the back of the notice to which it refers by a pin or paper fastener.

The Board will accept as satisfactory evidence of age a CERTIFIED EXTRACT FROM A PUBLIC REGISTRY OF BIRTHS, and if such certified extract cannot be obtained, a statutory declaration from a parent or guardian, stating, in the prescribed form, the date of birth, and also specifying (*a*) declarant's means of knowing the date of birth. as so stated, and (*b*) the reasons on account of which a certified extract from a public registry of births cannot be obtained.

The following will not be accepted as evidence of age:—

- **(*a*) Baptismal Certificates.**
- **(*b*) Certificates of Registry of Birth;**
- **(*c*) Certified extracts from public registries of birth issued under :—**
    - **(1) The Factory and Workshop Act, 1901; or**
    - **(2) The Irish Education Act, 1892; or**
    - **(3) The Friendly Societies' Act, 1896.**

CERTIFIED EXTRACT FROM A PUBLIC REGISTRY OF BIRTHS.

Application for such extract, in the case of any person born in Ireland, should be made to the Registrar-General, Charlemont House, Dublin, or to the Clerk of the Union in which the birth took place, or to the local Registrar of Births. Such application must be accompanied by a remittance of 3*s*. 7*d*., Registrar's Fee.

Under no circumstances should any additions to, or alterations in, such Certified Extract be made after its issue by a Registrar.

If the Christian name of the student be not given in the certified extract, such extract must be supplemented by a statement by a parent or guardian identifying the student who signs the notice of intention to present for examination with the person whose certificate of birth is furnished.

Forms for such statements can be obtained on application to the Assistant Commissioners.

FORMS FOR STATUTORY DECLARATION AS TO AGE. (Rules 18 and 78.)

No statutory declaration as to age, offered in lieu of an extract from a public registry of births, will be received except on the Form specially provided by the Board and supplied from the Office.

In the case of students not entered for the general examination, the Board, for the purpose of a choir or orchestra, may accept as evidence of age a statutory declaration as to age, on the prescribed form to be obtained from the office. One general statutory declaration made by the manager of the school will suffice for all such students in any one choir or orchestra. This declaration is to be transmitted to the office together with the prescribed February Forms (Rules 76 and 81) not later than the last day of February.

Applications for these Forms of Declaration must state the purpose for which the form is required, and in the case of choirs or orchestras the number of students, and must be accompanied by a Postal or Post Office Order (made payable to the Assistant Commissioners) for the Stamp Duty of 2*s*. 6*d*., payable on each Form: Postage Stamps or Cheques will not be accepted.

STUDENTS WHO PREVIOUSLY FURNISHED EVIDENCE OF AGE.

In the case of a student who gave notice of intention to present for examination in a previous year, and furnished satisfactory evidence of age, such evidence need not again be furnished.

RETURN OF CERTIFICATES OF AGE TO STUDENTS.

All certificates of age are retained in the Office for twelve months, after the expiration of which time they will be returned if then applied for—*the application to be accompanied by 1d. stamp for postage, and a statement of the year in which the certificate was lodged in the Office.*

Forms of application for return of certificates of age can be obtained from the Office.

MAY DECLARATIONS. (Rules 23 and 24).

Earliest day for making application for the prescribed forms of managers' declaration and private students' declarations as to students having pursued a course of study in Ireland, 15th April, 1907.

DATES ON WHICH APPLICATIONS FOR EXAMINERSHIPS AND APPLICATIONS FOR SUPERINTENDENTSHIPS SHOULD BE SENT TO THE BOARD.

Earliest day for sending to the Board applications for examinerships, 1907, 15th September, 1906.

Latest day for sending to the Board applications for examinerships, 1907, 15th October, 1906.

Earliest day for sending to the Board applications for superintendentships, 1907, 15th January, 1907.

Latest day for sending to the Board applications for superintendentships, 1907, 15th February, 1907.

THE BURKE MEMORIAL PRIZES.

The following are the Rules regulating the award of the Burke Memorial Prizes:—

I. The annual Income from the fund shall be applied in paying three Prizes, one of £16, one of £10, and a second of £10; any surplus or deficiency to be apportioned in the same ratio. If, in the opinion of the Commissioners, sufficient merit be not shown by the Candidates competing, to justify the award of any or either of the Prizes, the amount of such Prize may be, at the discretion of the Board, withheld and added to the principal.

II. No student shall be qualified to receive these Prizes except the children of persons who are, or have been, in receipt of salary or pension in Ireland, paid out of money derived from Parliamentary Grants, Rates, or Taxes, other than Members of the Naval or Military Services not being also in Civil employment.

III. The Prizes shall be awarded as follows :—that of £16 to the boy whom, at the annual examination in the Junior Grade among male candidates qualified in the manner expressed in the next preceding Rule, the Board shall adjudge to be the best answerer; One Prize of £10 to the boy whom, in the same Grade at such Examination, the Board shall adjudge to be the next best answerer; and the other of £10 to the girl whom, at such Examination in the same Grade, among female candidates qualified in the manner aforesaid, the Board shall adjudge to be the best answerer.

IV. The decision of the Board shall be final and decisive in determining whether the candidates fulfil the conditions of the third Rule.

V. The Board may deduct all expenses connected with the trust from the yearly income.

Copies of the form to be filled up by intending candidates, will be supplied on application (after 1st January, 1907) to the Assistant Commissioners—such application to be accompanied by a stamped directed envelope.

PREPARATORY GRADE PRIZE FUND SCHEMES.

Earliest day for transmitting to the Board ,Schemes for the Application of the Preparatory Grade Prize Fund, September 15th, 1907. Latest day for same, October 1st, 1907.

CLAIMS FOR SCHOOL GRANT, 1907.

Copies of the prescribed Form for the above, may be obtained on application to the Assistant Commissioners, not earlier than 1st October, 1907.

LISTS OF PUPILS ON ROLLS OF SCHOOLS ON 15th OCTOBER, 1907.

Copies of the prescribed Form for the above, may be obtained on application to the Assistant Commissioners, not earlier than 1st October, 1907.

ADVANCES TO MANAGERS OF SCHOOLS.

Forms of applications for advances to managers of schools for the purpose of providing equipment and appliances for the teaching of practical science, may be obtained on application to the Assistant Commissioners.

EXEMPTION FROM SCIENCE, 1906-7. (Rule 11.)

Applications for exemption should be made on the prescribed form, and should be transmitted to the Board not later than the first day of December, 1906.

Copies of the prescribed form may be obtained on application to the Assistant Commissioners.

T. J. BELLINGHAM BRADY,

SWIFT PAINE JOHNSTON,

Assistant Commissioners.

1 Hume-street, Dublin
April, 1906.

THE EXAMINATION PAPERS, 1906.

A reprint of the Examination Papers set in 1906 will be prepared in due Course, and may be obtained, price 2*s.* net, by post 2*s.* 3*d.*, through the Booksellers to the Board, as under :—

Messrs. Hodges, Figgis & Co., 104, Grafton-street, Dublin.
Messrs. M. H. Gill & Son, 50, Upper Sackville-street, Dublin.
Messrs. Browne & Nolan, Ltd., 24, Nassau-street, Dublin.
Messrs. W. Mullan & Son, Belfast.
Mr. W. Erskine Mayne, Donegall-square, Belfast.
Messrs. D. Mulcahy & Co., 36, Patrick-street, Cork.
Messrs. W. & T. Evans, 11, Patrick-street, Cork.
Messrs. O'Mahony & Co , 120, George-street, Limerick.
Mr. George D. Croker, Waterford.
Messrs. Getz & Co., 78, Quay, Waterford.
Mr. Thomas M'Cullagh, Eyre-square, Galway.
Mr. John Forrester. Londonderry.

THE EXAMINATION PAPERS,

1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1904, and 1905.

Copies of the reprints of the Examination Papers, 1895, 1896, 1897, 1898, 1899, 1900, 1901, 1902, 1904, and 1905, may still be obtained, through the Booksellers to the Board, price 2*s.* net; by post 2*s.* 3*d.*

INTERMEDIATE EDUCATION BOARD FOR IRELAND.

RULES AND PROGRAMME OF EXAMINATIONS

FOR 1907.

SEALED 19th JUNE, 1906.

PRESENTED IN PURSUANCE OF THE INTERMEDIATE EDUCATION (IRELAND) ACT, 1878, *Section* 6.

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1906

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Intermediate Education Board for Ireland.

Intermediate Education (Ireland) Acts, 1878 to 1900.

Commissioners :

THE RIGHT HON. CHRISTOPHER PALLES, LL.D., Lord Chief Baron of the Exchequer in Ireland, *Chairman.*

THE RIGHT HON. MR. JUSTICE MADDEN, M.A., LL.D., *Vice-Chairman.*

THE RIGHT HON. O'CONOR DON, LL.D., H.M.L.

THE REV. W. TODD MARTIN, D.LIT., D.D.

HIS GRACE THE MOST REV. WILLIAM J. WALSH, D.D., Archbishop of Dublin.

SAMUEL DILL, ESQ., M.A., LITT.D., LL.D

REV. T. A. FINLAY, M.A., F.R.U.I.

RIGHT REV. GERALD MOLLOY, D.D., D.SC.

W. J. M. STARKIE, ESQ., M.A., LITT.D.

REV. J. P. MAHAFFY, C.V.O., D.C.L., S.F.T.C.D.

F. A. TARLETON, ESQ., LL.D., SC.D., S.F.T.C.D.

HIS HONOUR JUDGE CRAIG, M.A.

Assistant Commissioners :

T. J. BELLINGHAM BRADY, ESQ., M.A., LL.D.
SWIFT PAINE JOHNSTON, ESQ., M.A.

All Communications should be addressed " THE ASSISTANT COMMISSIONERS,"
1, *Hume-street, Dublin.*

Intermediate Education Board for Ireland.

RULES.

The Intermediate Education Board for Ireland, in pursuance and by virtue of the "Intermediate Education (Ireland) Acts, 1878 to 1900," do hereby, with the approval of Their Excellencies The Lords Justices General and General Governors of Ireland make the following Rules for the purposes of the said Acts:—

SECTION I.

General Provisions regarding the examinations.

1. Examinations in accordance with the following rules will be held in each year, between the first day of June and the first day of August (except in the practical portion of the examination in music and in experimental science) at convenient centres, which will be selected by the Board with the approval of the Lord Lieutenant.

Examinations by printed papers.

2. All the examinations (except in the practical portion of the examination in music and in experimental science) will be conducted by printed papers, unless when otherwise directed in programme.

3. Public notice will be given by the Board of the times at which the written examinations will be held.

Preparatory Grade.

Pass and Honour Courses.

4. There will be the following Grades, and Courses, viz.:—

A. a Preparatory Grade, without honours, medals, or exhibitions.

B. four distinct Pass and Honour Courses, viz.:—

- (i.) the Classical Course;
- (ii.) the Modern Literary Course; { Division I. / Division II.
- (iii.) the Mathematical Course;
- (iv.) the Experimental Science Course.

Grades.

Each of the above courses will be divided into three Grades, viz.:—

the Junior Grade;
the Middle Grade;
the Senior Grade.

Examination of girls. 5. The examination of girls will be held apart from that of boys, except in cases which will be ordered by the Board.

Subjects in which a pass may be obtained. 6. The following will be the subjects in which a pass may be obtained in all grades :—

The ancient language, literature, and history of **Greece**;
The ancient language, literature, and history of **Rome**;
English Literature and **Composition** ;
History and **Geography**;
The **French** language;
The **German** language;
The **Irish** language;
The **Italian** language;
The **Spanish** language;
Arithmetic;
Algebra;
Geometry;
Experimental Science;
Music.

Together with the following for particular grades :—

Shorthand, Junior Middle, and Senior Grades;
Book-keeping, Junior, Middle and Senior Grades;
Natural Philosophy, Middle and Senior Grades;
Trigonometry, Middle and Senior Grades.

Subjects in which honours may be obtained. 7. The following will be the subjects in which honours may be obtained in the Junior, Middle, and Senior Grades :—

The ancient language, literature, and history of **Greece**;
The ancient language, literature, and history of **Rome**;
History and **Geography;**
The **French** language;
The **German** language:
The **Irish** language;
The **Italian** language;
The **Spanish** language;
Geometry;
Algebra ;
Experimental Science.
Together with **Trigonometry** for Middle and Senior Grades.

8. The Programme of the examinations in the several subjects of examination is set forth in the Schedule hereto.

SECTION II.

Special Regulations as to Experimental Science.

Order of subjects.

9. (*a*) The courses included under the title of experimental science and the order in which they are to be taken, are as follows :—

PRELIMINARY COURSE.

For the first year :—
Experimental Science and Drawing (First Year Syllabus).
For the second year :—
Experimental Science and Drawing (Second Year Syllabus).

SPECIAL COURSES

For the third year :—
Physics,
Chemistry,
Mechanics,
Botany,
Domestic Economy,
Physiology and Hygiene,
Drawing.
For the fourth year :—
Physics,
Chemistry,
Mechanics,
Botany,
Domestic Economy,
Physiology and Hygiene,
Geology,
Drawing.

Conditions of pass.

(*b*) To pass in experimental science, a student must be certified by the Department to have fulfilled the following conditions :—

(1.) To have followed the prescribed course of instruction in a school approved by the Department (see (*d*) *infra*).

(2.) To have been registered (on the Department's Forms) as having been in attendance at instruction in each of the prescribed subjects of the course on or before the 1st day of November.

(3.) To have obtained during the session, as a minimum :—
In a Preliminary Course one hundred hours' instruction, including at least sixty hours' instruction in Science, and at least twenty hours' instruction in Drawing, or
In a Special Course, seventy-five hours' instruction.

(4.) To have worked through the prescribed course to the satisfaction of the Department's Inspector, who may test the student in such a manner as he deems necessary.

Honours. (*c*) To pass, with honours, a student must :—

(1.) Fulfil the pass conditions in the course or courses in which they present themselves.

(2.) Pass in the same course or courses a qualifying practical test by an Inspector of the Department.

(3.) Obtain not less than 50 per cent. on the examination paper in the course or courses.

Conditions of approval of Schools. (*d*) To be approved by the Department a school must satisfy the following conditions :—

(1.) The accommodation and equipment must be adequate.

(2.) The instruction in the courses in experimental science, must be under teachers whose qualifications have been recognised in writing by the Department.

(3.) The time table of the course of instruction must be approved by the Department, and the course must be continuous throughout the session.

(4.) The Inspectors must satisfy themselves that the instruction is of a class superior to that given in elementary schools.

(*e*) Passes in one or more of the special courses will count as passes in one or more *subjects* for the purposes of Section IX.

(*f*) A student may not take one of the courses for the third or fourth year in the same year with either the course for the first year or for the second year ; but a student taking any fourth year course in the prescribed order, may, at the same time, take any course for the third year in which he has not already passed.

Repetition. (*g*) A student may obtain a pass or honours in a course of any year twice, but only twice. No student can obtain a pass or honours in any course lower than that in which he has already passed.

SECTION III.

Compulsory Preliminary Course in Experimental Science.

Compulsory preliminary Courses. 10. The two years' preliminary course of Experimental Science will be compulsory on all students of Intermediate schools except—

(*a*) Students who present themselves for examination in both Greek and Latin ;

(*b*) girls passing under the conditions of Rule 35.

11. Exemptions may be granted from the compulsory enforcement of experimental science in the case of schools which shall satisfy the Board that they are unable to provide the necessary equipment or teaching staff, or to obtain instruction for their pupils in a laboratory approved by the Department. When exemption is granted on this ground, students must take either Latin or a second mathematical subject as an alternative for experimental science. **Exemption.**

SECTION IV.

Special Regulations for the examination in Music.

12. (*a*) The examination will include both theory and practice. The programmes in theory for the various Grades are contained in the Programme for Music :— **Two parts of examination in music.**

For the Preparatory Grade, No. 7 of the Programme.
" " Junior " No. 8 " "
" " Middle " No. 8 " "
" " Senior " No. 8 " "

(*b*) No student who has not been certified by the examiner to have passed the practical examination will be admitted to the examination in theory. The maximum of marks assigned to the practical test, will bear to the maximum of marks assigned to the examination in theory the proportion of five to three. **Relation between two parts of examination.**

(*c*) Students presenting themselves in any grade above the Preparatory for examination in the theory of music may present themselves in the programme of the Practical Examinations of either Junior, Middle, or Senior Grade, that is, such students may take the course for any Grade above the Preparatory for the practical test, but for the theoretical examination they must take the course prescribed for the Grade in which they present themselves for the general examination. **Latitude allowed in selecting Grades.**

(*d*) No student will be adjudged to have passed in music who shall not have obtained at least 30 per cent. of the marks allotted to the practical part, and 30 per cent. of the marks allotted to the theoretical part of the examination. **Conditions of a Pass.**

(*e*) In the practical test the examiners may question the students as to their general knowledge of music.

(*f*) In all cases scales and arpeggios are to be played from memory, and as quickly as is consistent with accuracy.

(*g*) In the practical test of students in music no person but the student under examination shall be allowed in the room with the examiners.

SECTION V.

Students not eligible for examination.

Students ineligible for examination in any Grade.

13. A student will be ineligible for examination in any Grade
- (*a*) who has not pursued a course of study in Ireland for the full period of the educational year preceding the date of examination;
- (*b*) who is a matriculated student of a university;
- (*c*) whose age on the first day of June preceding the examination is under 13 or over 19 years.

For the purpose of these rules a student whose birthday occurs on 1st June may be deemed to be under the age which he completes on that day.

Students ineligible for examination in particular Grades.

14. A student will be ineligible for examination
- (*a*) in a Grade lower than one in which he has formerly passed, or
- (*b*) in a Grade in which he has already twice passed, or
- (*c*) in a Grade in which he obtained an exhibition of the highest value, or
- (*d*) in the Preparatory Grade if his age on the first day of June preceding the examination is over 15 years.

SECTION VI.

Notices and declarations to be sent in by students, and by managers, and other matters preliminary to the examinations.

Student's February Notice.

2s. 6d. stamp.

10s. stamp.

15. Students intending to present themselves for examination shall transmit to the Board, in the prescribed form,* notice of their intention, together with satisfactory evidence of age. The notice shall specify the grade and the subjects in which, and the centre at which, the student proposes to present himself; and shall be stamped with an Intermediate Education stamp of 2*s*. 6*d*., if the same together with the evidence of age be transmitted to the Board not later than the last day of February, and with a stamp of 10*s*., if such notice or evidence be transmitted after that day, and not later than the 31st day of March. If the notice or evidence be transmitted after the 31st day of March, the student will not be allowed to present himself for examination. The examination of the student will be limited to the subjects specified in his notice.

Music.

16. Students intending to present themselves for examination in music shall transmit to the Board, in addition to the notice under Rule 15, notice of such intention in the prescribed form,* stamped

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* These forms can be obtained *only* from the several Stamp Distributors and Postmasters anthorized to sell Inland Revenue Stamps throughout Ireland, and in Dublin from the licensed Vendors of Stamps; *they are not procurable at the Office* 1, *Hume-street*.

with an Intermediate Education stamp of 10*s.* 6*d.*, to be transmitted to the Board not later than the last day of February.

Music Lists.

17. Each manager of a school shall transmit to the Board, not later than the last day of February, a list, on the prescribed form,* of the names of the students of his school who intend to present themselves for examination in music.

Evidence of Age.

18. The Board will accept as satisfactory evidence of age a certified extract from a public registry of births, or if such certified extract cannot be obtained, a statutory declaration from a parent or guardian, stating, in the prescribed form, the date of birth, and also specifying

(*a*) declarant's means of knowledge of the date of birth as so stated, and

(*b*) the reasons on account of which a certified extract from a public registry of births cannot be obtained.

Memorial Prizes.

19. Subject to the exception in the next following rule a candidate for a Burke Memorial prize shall, not later than the 31st March, transmit to the Board, in the prescribed form,* the further particulars necessary to show that he is entitled to compete.

20. A candidate whose father becomes entitled after the 31st March to such salary or pension as qualifies his children to compete for these prizes may transmit these particulars at any time previous to the first day of the examinations.

Examination No.

21. Each student will be assigned a number by which alone he shall be known in the subsequent written examination.

Admission Card.

22. No student will be admitted to the examination without an admission card.

Such admission card will not be issued unless a declaration as to a course of study shall have been received in the case of each student under Rules 23 or 24.

May Declaration for Schools.

23. Each manager who intends to claim a school grant, shall, on or after the first, and not later than the 21st, day of May, transmit to the Board a declaration, in the prescribed form,* signed by him,

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* Copies of the prescribed form may be obtained on application to the Assistant Commissioners.

stating the names of the students upon the roll of his school who have pursued their studies in his school during the educational year then current, and the subjects, if any, of those specified in their February notices under Rule 15, in which they propose to present themselves for honours, and in the case of each candidate for an exhibition or prize, the course in which he elects to be examined.

Candidates for exhibitions must select not more than one course in which they will present themselves for examination.

May Declaration for students not on a school roll.

24. A student whose name is not on the roll of an Intermediate school, or whose name is not included in the declaration of a manager under the last preceding rule, shall after the 21st of May and not later than the 1st of June, transmit to the Board, in the prescribed form,* a declaration to the effect mentioned in such rule, made by himself, and certified as correct by his parent or guardian.

SECTION VII.

Conduct of students during the examination.

25. When presenting himself for examination in geometry each student shall bring with him a graduated ruler, compasses, and set squares.

Rules for direction of students.

26. A student shall not bring into the examination room, or have in his possession, or under his control, or within reach, whilst he is in such room,

(*a*) any book or paper (save his admission card, the examination paper, and such answer books as shall have been supplied to him by the superintendent); or

(*b*) any slate, memorandum or notes.

27. A student shall not, while in the examination room,

(*a*) use, or attempt to use, any book, memorandum, notes, or paper (save the examination paper, and such answer books as shall have been supplied to him by the superintendent); or

(*b*) aid, or attempt to aid, another student; or

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* Copies of the prescribed form may be obtained on application to the Assistant Commissioners.

(*c*) obtain, or attempt to obtain, aid from another student; or

(*d*) communicate, or attempt to communicate, in any way with another student.

Any student found by the superintendent violating this rule or Rule 26 will be expelled from the examination room, and will not be permitted to return to it during the continuance of the examination in the subject in which the examination papers shall have been then distributed.

28. A student

(*a*) shall not write on the examination paper;

(*b*) shall not remove from the answer books, any leaf, or part of a leaf;

(*c*) shall not take out, or attempt to take out, of the examination room, any answer books, whether used o unused;

(*d*) shall not damage the examination room or its furniture;

(*e*) shall, immediately after he has concluded his answers, deliver his answer books, whether used or unused, enclosed in an envelope endorsed with his examination number, and also his examination paper (except at the close of the period allotted for the examination) to the superintendent, and shall then leave the examination room; and

(*f*) shall, in all matters relative to the examination, submit to, and obey, the directions of the superintendent.

Penalty for Violation of Rules.

29. Any student adjudged by the Board to have violated any of the Rules 26, 27, or 28 will be liable to be deprived of the examination or of marks, or to have such deduction made, as the Board may think fit, from any sum payable in respect of any prize or exhibition obtained by him, according to the judgment the Board may form of the gravity of the offence; and the Board may, if they think fit, publish his name and address, as given in his notice of intention to present himself for examination, as those of a student who has been so deprived.

30. In all subjects in which pass and honour papers are set, both papers will be distributed simultaneously, but each student will receive but one paper in accordance with the notice given under Rules 15, 23, and 24.

SECTION VIII.

Conditions of passing the examination in particular subjects.

Pass.

31. No student will be adjudged to have passed the examination in any subject, except those specified in Rules 9 and 12, who shall not have obtained
    (1) 30 per cent. on the pass paper in any subject; or
    (2) 20 per cent. on the honour paper in any mathematical subject; or
    (3) 25 per cent. on the honour paper in any other subject.

Special condition for languages.

32. No student will be adjudged to have passed in Greek, Latin, French, German, Irish, Italian, or Spanish, who shall not have obtained at least 20 per cent. of the marks assigned in any of these languages to translation from English into that language.

33. No student will be adjudged to have passed in English Literature and Composition, who shall not have obtained at least 30 per cent. in English Literature and 30 per cent. in Composition.

SECTION IX.

Conditions of passing the examination generally.

34. In all the Grades, students may present themselves in any number of subjects but, except as provided in Rules 35 and 36, to pass the examination they must pass in the subjects as set forth for the several Grades and Courses in the following scheme :—

PREPARATORY GRADE.

(A)—English Literature and Composition.
(B)—One of the following subjects :—
  (1) Latin, (2) French, (3) German, (4) Irish.
(C)—Arithmetic or Algebra.
(D)—Experimental Science.*
(E)—One other subject.

JUNIOR GRADE.

I.—*The Classical Course.*

(A)—English Literature and Composition.
(B)—Latin.
(C)—Greek.
(D)—One of the following subjects, viz. :—
  (1) Arithmetic, (2) Geometry, (3) Algebra.
(E)—Two other subjects.

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* See Rule 9.

II.—*The Modern Literary Course.*

(A)—English Literature and Composition.
(B)—Two of the following subjects :—(1) French ; (2) German ; (3) Irish ; (4) Italian ; (5) Spanish.
(C)—One of the following subjects :—(1) Arithmetic ; (2) Geometry ; (3) Algebra.
(D)—Experimental Science.*
(E)—One other subject.

Students who have worked through the two years' preliminary course of Experimental Science, may substitute Latin under (D).

III.—*The Mathematical Course.*

(A)—English Literature and Composition.
(B)—Arithmetic.
(C)—Geometry.
(D)—Algebra.
(E)—One of the following subjects :—(1) Latin ; (2) French ; (3) German.
(F)—Experimental Science.*

Students who have worked through the two years' preliminary course of Experimental Science, may substitute Latin under (F).

IV.—*The Experimental Science Course.*

(A)—English Literature and Composition.
(B)—Experimental Science.*
(C)—One of the following subjects :—(1) Arithmetic ; (2) Geometry ; (3) Algebra.
(D)—French or German.
(E)—Two other subjects.

MIDDLE GRADE.

I.—*The Classical Course.*

(A)—English Literature and Composition.
(B)—Latin.
(C)—Greek.
(D)—One of the following subjects :—(1) Arithmetic ; (2) Geometry ; (3) Algebra.
(E)—Two other subjects.

II.—*The Modern Literary Course.*

(A)—English Literature and Composition.
(B)—Two of the following subjects:—(1) French ; (2) German ; (3) Irish ; (4) Italian ; (5) Spanish.
(C)—One of the following subjects :—(1) Arithmetic ; (2) Geometry ; (3) Algebra.
(D)—Experimental Science.*
(E)—One other subject.

Students who have worked through the two years' preliminary course of Experimental Science, may substitute Latin under (D).

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* See Rule 9.

III.—*The Mathematical Course.*

(A)—English Literature and Composition.
(B)—Arithmetic.
(C)—Geometry.
(D)—Algebra.
(E)—One of the following subjects :—(1) Latin ; (2) French ; (3) German.
(F)—Experimental Science.*

Students who have worked through the two years' preliminary course of Experimental Science, may substitute Latin under (F).

IV.—*The Experimental Science Course.*

(A)—English Literature and Composition.
(B)—Experimental Science.*
(C)—One of the following subjects :—(1) Arithmetic ; (2) Geometry ; (3) Algebra.
(D)—French or German.
(E)—Two other subjects.

SENIOR GRADE.

I.—*The Classical Course.*

(A)—English Literature and Composition.
(B)—Latin.
(C)—Greek.
(D)—One of the following subjects :—(1) Arithmetic ; (2) Geometry ; (3) Algebra ; (4) Trigonometry.
(E)—Two other subjects.

Girls may take, instead of (D), a third additional subject in (E).

II.—*The Modern Literary Course.*

(A)—English Literature and Composition.
(B)—Two of the following subjects :—(1) French ; (2) German; (3) Irish ; (4) Italian ; (5) Spanish.
(C)—One of the following subjects :—(1) Arithmetic ; (2) Geometry ; (3) Algebra ; (4) Trigonometry.
(D)—Experimental Science.*
(E)—One other subject.

Girls may take, instead of (C), an additional subject in (E).

III.—*The Mathematical Course.*

(A)—English Literature and Composition.
(B)—Algebra.
(C)—Geometry.
(D)—Trigonometry.
(E)—One of the following subjects :—(1) Latin ; (2) French ; (3) German.
(F)—Experimental Science.*

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* See Rule 9.

IV.—*The Experimental Science Course.*

(A)—English Literature and Composition.
(B)—Experimental Science.*
(C)—One of the following subjects:—(1) Arithmetic; (2) Geometry; (3) Algebra; (4) Trigonometry.
(D)—French or German.
(E)—Two other subjects.

Special Provision Pass Examination Girls. 35. In the Junior, Middle, and Senior Grades, girls may present themselves for examination in English Literature and Composition, and in the honour papers of any three other subjects of the Programme. They will be deemed to have passed the examination if (*a*) they pass in English Literature and Composition; (*b*) obtain honours in at least one of three honour subjects, and (*c*) obtain in any of such subjects in which they do not obtain honours the percentage stated in Rule 31, (2) and (3).

Principle of Average. 36. If a student obtain less than 30 per cent. in any one of the subjects prescribed, but not less than 25 per cent., he shall be adjudged to have passed the examination generally, provided the aggregate of his marks in all the subjects is equivalent to an average of 30 per cent. in each.

If a student take honour papers in any subject, the marks obtained will be increased, for the purpose of a pass, by 50 per cent. in the case of mathematical papers, and 20 per cent. in the case of other papers.

For the purposes of this Rule a student who obtains a pass in Experimental Science shall be deemed to have obtained 30 per cent. in that subject.

SECTION X.

Honours, medals, and exhibitions.

Honours. 37. To obtain honours in any honour subject, students must obtain 50 per cent. on the honour paper, except in the mathematical subjects in which it will be sufficient to obtain 35 per cent.

38. No student will be awarded honours in Greek, Latin, French, German, Irish, Italian, or Spanish, who shall not have obtained at least 40 per cent. of the marks assigned in any of these languages to translation from English into that language.

Pass with Honours. 39. A student will be adjudged to have passed with honours who shall have passed the examination in any course, and shall have obtained honours in at least three subjects.

Exhibitions 40. Exhibitions, tenable for one year, the highest of which will not exceed in value the following sums, viz.:—in the Junior Grade £15, in the Middle Grade £25, and in the Senior Grade £40, will be awarded in each Course to such students in the Junior, Middle, and Senior Grades respectively, as the Board shall adjudge to have passed with honours and to have obtained the highest totals of honour marks, subject to the provisions of Rules 41 and 43.

*See Rule 9.

Marks counting for Exhibitions.

41. Marks on the honour paper in not more than four subjects in addition to the excess of marks above 50 per cent. obtained in English Literature and Composition, will count towards exhibitions. The marks counted towards exhibitions will be, in each subject, the excess of marks obtained above the standard necessary to obtain a pass in the honour paper of that subject, and in Experimental Science, the excess of marks above 25 per cent.

Courses for Exhibitions

42. Exhibitions can be obtained in any one of the courses of Rule 34, viz. :—

I. the Classical Course.
II. the Modern Literary Course;
III. the Mathematical Course;
IV. the Experimental Science Course.

To be eligible for exhibitions in any Course students must pass with honours in that Course, and obtain honours in the following subjects in such course, hereinafter called the *main subjects* :—

(I.) for the Classical Course, in Greek and Latin.
(II.) for the Modern Literary Course :
  Division I. in either French or German and in Irish.
  Division II. in French and German.
(III.) for the Mathematical Course, in the Junior and Middle Grades in
  (1) Algebra; and
  (2) Geometry,
and in the Senior Grade in
  (1) Algebra; and
  (2) Geometry or Trigonometry.
(IV.) for the Experimental Science Course in
  (1.) (*a*) one of the Preliminary Courses of Experimental Science and Drawing, *or*
    (*b*) a special course in Physics, Chemistry or Mechanics, or Botany (for Girls),
  (2.) Algebra or Geometry.

Special Paper for exhibitions and medals.

43. In addition to the general honours examination candidates for exhibitions, prizes and medals will be further examined in a more searching paper in each of the *main subjects* of the course selected by them, and the marks for this paper will be the same as for the corresponding honour paper. The marks gained by the candidate on such further paper, computed as provided by Rule 41, will be added to those gained on the honour paper in the same subject.

Students ineligible by age for prizes and exhibitions.

44. A student will be ineligible for prizes, medals, or exhibitions whose age on the first day of June preceding the examination shall exceed—

16 years in the case of Junior Grade students.
17 „ „ Middle Grade „
18 „ „ Senior Grade „

45. Any student who is a candidate for an exhibition in a grade in which he has already been awarded an exhibition will not be eligible for an exhibition except it be of a higher class than that previously awarded.

Number of exhibitions.

46. In determining the number of exhibitions in each Grade and Course the Board will have regard to the number and excellence of the passes with honour in such Grade and Course.

47. There will be no competition for exhibitions or prizes between students in different courses or in the different divisions of the Modern Literary Course.

Separate awards for boys and girls.

48. In awarding exhibitions, separate awards will be made for boys and girls.

Exhibitions may be applied to provide for education of student in a school.

49. The Board may direct that the payments in respect of any exhibitions in the Junior and Middle Grades shall be subject to the condition that the amount shall be applied to provide for the future education of the student in a school to be selected by the parent or guardian of the student, subject to the approval of the Board, and the amount of the exhibition shall be paid to the manager of such school and shall be applied for the education, maintenance, expenses of attending school, or otherwise for the benefit, of the student, upon such terms as shall be agreed upon between the parent or guardian and the manager, subject to the approval of the Board. Every agreement under this rule shall be on the prescribed form, and shall be lodged with the Board within such time as may be prescribed.

Exhibitions may be applied by the Board for the benefit of student.

50. The Board may direct that the amount of any exhibition in the Junior, Middle, or Senior Grade, instead of being paid to the student, or applied in the manner prescribed by the preceding rule, shall be applied in or towards the payment of any sums due to the manager of a school for the student's education or maintenance as a pupil at a school during the educational year in which the exhibition was obtained, or in or towards the payment of the cost of obtaining further or more advanced or special education or instruction, or in or towards the payment of fees, premiums, or expenses required for enabling the student to prepare or qualify for a suitable calling or employment, or otherwise for his permanent benefit and advancement in life.

Statement of intention

51. A student who has obtained an exhibition shall before the 1st day of the following October transmit to the Board a statement of the mode within either of the two last preceding rules in which he may desire the amount of his exhibition to be applied in the event of the Board determining that the same shall not be paid to him directly.

Such statement shall be in the prescribed form and shall be signed by the student and his parent or guardian.

Certificates, under-takings, &c. from managers, parents, &c.

52. In order to satisfy themselves that the payments in respect of exhibitions are or shall be applied in accordance with the purposes of the preceding rules, the Board may call for such certificates, undertakings, or declarations, from the managers of schools, teachers, employers, parents, or others, or for such other evidence as the Board may in each case think necessary or sufficient; and may retain the amount of any exhibition pending the production of such evidence, and in any case in which the Board shall not be so satisfied before the student attains the age of nineteen years, the right to receive payment of the exhibition will cease, unless the Board shall otherwise direct.

Medals.

53. Medals, provided sufficient merit is shown, may be awarded to students in the Junior, Middle, and Senior Grades respectively, as follows:—

A bronze medal in each of the following subjects to the boy and to the girl who, having passed the examination generally, shall obtain the highest total marks on the honour paper and the further paper mentioned in Rule 43, viz.:—

1. in Greek;
2. in Latin;
3. in English literature and composition;
4. in history and geography;
5. in each modern language;
6. in geometry;
7. in algebra;
8. in trigonometry;
9. in experimental science.

Case of equality of marks.

54. If two or more students obtain equal marks, a larger number of medals may be awarded.

55. A student will not be awarded a medal a second time for the same subject, in the same Grade.

SECTION XI.

Prizes.

Prizes.

56. Prizes, in books, philosophical apparatus, or other objects useful for educational purposes, of the respective values of £3, £2, and £1, may be awarded to students who have passed with honours but failed to obtain exhibitions in the Junior, Middle, and Senior Grades.

Prizes for Composition.

57. Provided sufficient merit be shown, prizes in books, philosophical apparatus, or other objects useful for educational purposes

may be awarded to students, in the Junior, Middle, and Senior Grades, who shall have passed the examination, and shall have obtained the highest marks in English Composition, or in translation of English into any of the following languages :—

Greek, Latin, French, German, Irish, Italian, or Spanish.

Such prizes will be of the value of :—

£4 each, in the Senior Grade;
£3 in the Middle Grade; and
£2 in the Junior Grade.

Prizes to be subject to approval of Board.

58. All books, philosophical instruments, or other objects useful for educational purposes, selected as prizes, will be subject to the approval of the Board.

Special Prizes in Greek and German.

59. In Greek and in German, prizes may be awarded to students who have passed the examination and have obtained the highest marks in these subjects. Such prizes shall not exceed the value of :—

£10 each in the Senior Grade;
£7 each in the Middle Grade;
£5 each in the Junior Grade;
£3 each in the Preparatory Grade.

Preparatory Grade Prize Fund.

60. The Board have power to assign to such managers of schools as shall, before the 1st October, have submitted schemes in respect thereof to the Board, a sum of money calculated at a rate not exceeding £1 per pass in the Preparatory Grade, as a prize fund for that Grade, to be applied according to such schemes as shall have been sanctioned or altered by the Board.

SECTION XII.

Certificates.

Certificates of passing generally.

61. Certificates will be issued to all students who have passed the examination; such certificates will specify the subjects in which the students have passed, or have obtained honours.

Certificates for Music.

62. "Pass" Certificates and Certificates of a "Pass with distinction" will be issued on application to successful students at the examination in music, provided they have passed the general examination. To obtain the Certificate of a "Pass with distinction" marked proficiency must be shown, and students must present for the practical examination a programme not lower than that of the Grade in which they enter for the general examination.

No student will be awarded a certificate of a "Pass with distinction" who has not obtained at least 50 per cent. of the marks for the practical test and 50 per cent. of the marks for theory.

SECTION XIII.

School Grant.

Conditions to be observed by managers of schools. 63. The school grant will be paid to managers of schools who, in addition to observing the other rules of the Board, shall have complied with the following conditions, viz. :—

Inspection. (*a*) Each manager of a school shall, when required by the Board sign a consent, in the prescribed form, to have his school inspected, and shall permit his school to be inspected accordingly, and shall furnish to the Board or its inspectors the information which the Board shall deem needful for carrying out this inspection.

(*b*) He shall comply with the requirements of the Board as to the provision for health, recreation, sanitation, and physical exercise which the Board may judge necessary in the condition of the school.

Lists of Students. (*c*) He shall, not later than the 1st day of November next preceding the examinations, transmit to the Board a list, in duplicate, in the prescribed form,* of all the pupils, within the prescribed limits of age, who were on the roll of such school on the previous 15th of October.

May Declaration (*d*) He shall, within due time, sign the declaration prescribed by Rule 23, in the case of each pupil in respect of whom he intends to claim the school grant.

Claim before 15th October. (*e*) He shall, not later than the 15th day of October next after the examinations in respect of which the school grant may be claimed, transmit to the Board his claim, in duplicate, for such grant in the prescribed form.*

In respect of whom the School Grant payable. 64. The pupils in respect of whom the school grant shall be payable will be those only who shall have fulfilled the following conditions, viz. :—

Name on List. (1.) whose names shall appear on the list transmitted to the Board under Rule 63 (*c*) of the pupils who were on the roll of the school on the preceding 15th day of October.

100 Attendances. (2.) who shall have attended such school from the said 15th day of October, and shall each have made at least one hundred attendances at that school during the period from that date to the 31st day of May following, not more than one attendance being counted for each day.

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* Copies of the prescribed form may be obtained on application to the Assistant Commissioners, not earlier than 1st October.

65. The school grant will consist of (*a*) the normal school grant, and (*b*) the bonus school grant. **School Grant.**

(*a*) *The Normal School Grant.*

(1) A capitation grant will be made to the manager of every school for each student subject to the preceding rule who shall have passed the examination. The amount of this capitation grant will depend on the Grade and will be in such proportion for the several Grades respectively as the Board shall decide.

(2) The capitation grant will be increased in the case of honour students by such a percentage as the Board shall decide.

(3) The capitation grant, so computed, will be called the normal school grant.

(*b*) *The Bonus School Grant.*

If upon the reports of the inspectors, and considering all the circumstances of the case, the Board shall be of opinion that the education in a school is of a highly satisfactory character, they may increase the normal school grant payable in respect of such school by a sum not exceeding 20 per cent. thereof, and if they are of opinion that such education although not highly satisfactory is yet satisfactory, by a sum not exceeding 10 per cent. thereof.

SECTION XIV.

Bonus for Choirs and Orchestras.

66. With a view to encourage Choral Singing and Orchestral Music in Intermediate Schools, the Board shall have power to grant a special bonus to the schools which present for examination a choir or orchestra which shall acquit itself to the satisfaction of the examiners. **Bonus.**

67. The choir or orchestra must be composed exclusively of pupils actually attending the school, but may contain up to 70 per cent. of students under thirteen years of age. The number in a choir should include not less than 30 per cent. of the total number of pupils between the ages of 10 and 19, who have made at least 100 school attendances during the educational year. Students over the age of 19 years and under 10 years, provided they have made at least 100 school attendances, may be entered in choirs or orchestras, but they may not count in the calculation of the bonus. **Ages for choirs and orchestras.**

68. In the calculation of the bonus for choirs and orchestras account will be taken only of those students whose names appear on the prescribed February Forms for choirs and orchestras, and who are present at the examination. **Students in respect of whom bonus is payable.**

Maximum bonus. 69. The total bonus payable to a school for choir-singing or orchestral music, exclusive of any special bonus which may be granted in the case of the special examination of choirs and orchestras, may not exceed £80 in any case.

Pieces to be performed. 70. The examination of choirs and orchestras shall include the performance of a piece or pieces selected by themselves, and also an easy piece selected by the examiners, to be performed without previous preparation.

71. Under choral and orchestral music part-singing and chamber music are included.

72. All choir-singing is to be unaccompanied by any instrument.

73. In choir-singing and orchestral music the examiners may question the students as to their general knowledge of music.

Notice. 74. Managers of schools desiring to present a choir or orchestra for examination shall give notice of their intention in the prescribed form,* and submit the names of the pupils composing such choir or orchestra, with a programme of the music they intend to perform, and also the parts in which the pieces will be performed by the choir. The prescribed forms, together with a fee of £1 1*s.* each for choir and orchestra, shall be transmitted to the Board not later than the last day of February.

Evidence of age for choirs and orchestras. 75. In the case of students not entered for the general examination, the Board, for the purpose of a choir or orchestra, may accept as evidence of age a statutory declaration as to age, on the Form* specially provided by the Board and supplied from the Office. One general statutory declaration made by the manager of the school will suffice for all such students in any one choir or orchestra. This declaration is to be transmitted to the Office together with the prescribed February Forms (Section VI.) not later than the last day of February.

Applications for these Declaration Forms must give the number of students for whom the form is required, and must be accompanied by a Postal or Post Office Order (made payable to the Assistant Commissioners) for the Stamp duty of 2*s.* 6*d.*, payable on each Form. Postage stamps or cheques will not be accepted.

Special examination in Dublin. 76. The Board shall have power to hold in Dublin a special examination for choirs and orchestras of Intermediate schools, at which special prizes will be awarded. The date of these examinations will be announced in due course.

Notice for special examination. 77. Managers of schools desiring to present a choir or orchestra for the Special Examination shall give notice of their intention on the prescribed form,* and submit the names of the pupils composing such choir or orchestra, with a programme of the music they intend to perform, and also the parts in which the pieces will be performed by the choir.

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* Copies of the prescribed form may be obtained on application to the Assistant Commissioners not earlier than 1st February.

Fee for special examination.

78. The prescribed forms, together with a fee of £1 1s. each for choir and orchestra (in addition to the fee for ordinary examination), shall be transmitted to the Board not later than the last day of February. Copies of the prescribed form may be obtained on application to the Assistant Commissioners, not earlier than 1st February.

SECTION XV.

Advances to Managers.

Purpose of Advances.

79. The Board may, at their discretion, advance money to managers of schools upon approved security, to enable them to provide proper equipment and appliances for the teaching of practical science, and for similar purposes to be approved by the Board, and may agree to accept repayment of the money so advanced and interest by instalments.

Stipulation as to School Grant.

80. The Board, when it considers it just and expedient so to do, may stipulate with the manager of a school presenting pupils for examination in the natural and experimental sciences, that a certain portion of the school grant which shall thereafter become payable in respect of education in such school shall be applied in the provision of proper equipment and appliances for the practical teaching of these sciences in such school.

Repayment of Advance.

81. When such a stipulation has been made with the manager applying for an advance, the Board may agree with such manager that the amount of any instalment which shall accrue due on foot of the advance shall be deducted from the portion of the school grant for any future year which, by virtue of such stipulation, shall be applicable to the provision of the equipment and appliances in the last preceding rule mentioned, and in such case the Board may, notwithstanding any change in the managership of the school, deduct the amount of such instalment from such portion of the school grant for the future years.

Security.

82. An agreement under the last preceding rule for the repayment of an advance by instalments out of the portion of the school grant stipulated to be applied as mentioned in Rule 80, either by itself or together with such personal or other collateral security as the Board may, under all the circumstances of the case, think fit to require, may be approved by the Board, and when so approved shall be deemed to be approved security within the meaning of Rule 79, and of the Recommendations contained in the General Summary of the Report of the Commission mentioned in the Intermediate Education (Ireland) Act (1900).

SECTION XVI.

Finance.

83. All sums of money payable under the Intermediate Education (Ireland) Acts, 1878 to 1900, or under these or any future rules, and the expenses of carrying the Acts into execution—shall be paid out of the moneys of the Board generally.

SECTION XVII.

General Powers.

Power to enlarge time.

84. Subject to the restrictions contained in the next following section the Board may by order, either general or special, enlarge the time appointed by these rules for doing any act or class of acts, and such order shall be valid, although made after the time appointed for doing such act shall have expired.

Publication of Results.

85. The Board may publish such particulars of the results of their examinations and such other information relating thereto as they may think fit.

Decisions of Board final upon title to exhibitions, &c.

86. The decisions of the Board upon the title to exhibitions, prizes, medals, and school grants, upon the amounts of exhibitions, prizes, school grants, and bonuses, upon the mode of application of exhibitions, upon the equipment and appliances necessary to be provided for the teaching of practical science and for similar purposes, upon the amounts necessary to be advanced therefor, upon or in relation to the character of and approval of the security therefor, and upon any question which may arise upon the construction of their rules, shall be final and conclusive.

SECTION XVIII.

Special Powers of the Board in cases of unforeseen difficulties, accidents or breaches of rules.

Power of Board to order a second examination.

87. In case of the occurrence of accidents or irregularities, or under other special circumstances, the Board may order a second examination to be held at such centre or centres as they shall think fit, in any portion of the matter of examination; and the marks obtained at such second examination will, for all intents and purposes, be regarded as if they had been obtained at the first examination, unless the Board, when ordering the second examination to be held, shall otherwise direct.

88. In case a student, through any mistake, shall not be awarded the marks to which he is entitled on his answering, the Board may amend the award of the examiners in accordance with the facts, and adjudge such student to have passed, or to have passed with honours, or to have obtained an exhibition, a prize, or a medal, if he shall be entitled thereto by his marks as amended. **Power to amend awards of examiners.**

89. If the Board shall be of opinion that irregularities or malpractices have occurred at any centre, and from the nature or extent thereof shall come to the conclusion that the authorities or teachers of any school are to blame in the matter, they shall have power to direct that such school shall not be entitled to receive any school grant for such period as they may determine. **Power to disallow school grant in case of irregularities.**

90. In case a manager shall omit to transmit to the Board, before or on the 15th of October, his claim for a school grant, the Board may, in their discretion, permit the omitted claim to be received after that day; but the school grant payable in respect of such omitted claim will, unless the Board be satisfied of the sufficiency of the cause stated in explanation of the omission, be reduced by such sum not exceeding 10 per cent. as the Board may direct. **Late claims for school grant.**

91. In case a manager shall omit to transmit to the Board before or on the 1st November, the list of students upon the roll of the school on the 15th of October, the Board, if satisfied of the sufficiency of the cause stated in explanation of the omission, may, in their discretion, permit the omitted list to be received after that day, but the school grant which may become payable to such manager will be reduced by such sum not exceeding 25 per cent. as the Board may direct. **Late lists under Rule 63c.**

92. In case a manager shall omit from the list of students upon the roll of the school on the 15th of October, the name of any student who might have been included therein, the Board, if satisfied of the sufficiency of the cause stated in explanation of the omission, may, in their discretion, permit the list to be amended by adding thereto the omitted name or names. A sum of £1 for each name so omitted shall be deducted from the school grant which may become payable to such manager. **Omission of name from lists under Rule 63c.**

93. In case a manager who proposes to present a choir or orchestra for examination, or for the special examination in Dublin, shall omit to transmit to the Board before or on the last day of February, the list of students composing such choir or orchestra, the Board, if satisfied of the sufficiency of the cause stated in explanation of the omission, may, in their discretion, permit the omitted list to be received after that day, but the bonus which may become payable to such manager will be reduced by such sum not exceeding 25 per cent. as the Board may direct. **Late lists under Rules 74 and 77.**

94. Non-compliance by the Board with these rules shall not render void any of their acts.

SECTION XIX.

Definitions.

95. The following expressions in the rules are thus defined:—

"Department" means the Department of Agriculture and other Industries and Technical Instruction in Ireland and for other purposes connected therewith;

"educational year" means the period between the 15th day of October in any year and the 1st day of June in the succeeding year;

"experimental science" means the various courses specified in Rule 9 (*a*);

"honour subject" means any subject within Rule 7;

"honour marks" mean marks within the description in Rule 41;

"honour student" means any student who passes the examination with honours (Rule 39);

"manager" means "manager of a school;"

"prescribed form" means such form as may, from time to time, be prescribed by the Board;

"school" means any educational institution (not being a National school) whose teaching comprises any of the courses as defined in the Board's programme in any grade higher than the Preparatory, and whose list of students under Rule 63 (*c*) in the year of the examination, contains the names of at least seven students within the prescribed limits of age.

"student" includes girl as well as boy; and pronouns in the masculine gender include the corresponding pronouns in the feminine gender;

"subject" means any subject of examination in the programme;

"transmit" means to send by post or otherwise so as to reach the office within office hours on the day named in the Rule, or on the following day if the day named be a Sunday.

SECTION XX.

Commencement of rules.

96. These rules will come into operation on the 1st day of September 1906, but will not apply to anything in relation to the examinations which shall have been previously held. All prior rules inconsistent with any of these rules shall be revoked from the times when these rules respectively shall come into operation.

SCHEDULE

CONTAINING THE

PROGRAMME OF

EXAMINATIONS

IN THE

Preparatory, Junior, Middle, and Senior Grades

for 1907.

Preliminary Notes.

1. The Board do not, as a rule, recommend any particular text books. By "School Text" is meant some edition of the works referred to, which has been prepared for school use, and from which objectionable passages are omitted. The Board do not approve of the use of vocabularies where dictionaries are available.

2. In marking answer books regard will be had to spelling, handwriting, and the general neatness of the answers, and marks will be deducted from the total marks awarded to each answer-book for deficiencies in these points.

3. The questions on the pass examination papers are intended to be of such a character as may be answered by any student fairly well taught.

4. In the literary examinations in all Grades, but particularly in the Middle and Senior Grades, special credit will be given for the style of the translations from the classical or modern languages into English.

5. In the Preparatory and Junior Grades, knowledge of the prescribed authors in the various languages may be tested in parsing, analysis, paraphrasing, prosody, literature, history, and geography, by questions naturally arising out of the passages set for translation.

6. In the Preparatory and Junior Grades the passages for translation at sight will be chosen of a style and character similar to those of the authors prescribed; in the Middle and Senior Grades they will be chosen either from the authors prescribed as standards, or from others similar to them in style and character.

7. In the case of sufficient merit in Greek or Latin verse composition, additional marks may be awarded not exceeding 20 per cent. of the total honour marks in Greek or Latin obtained by the student. Full marks, however, may be obtained in Latin and Greek without verse composition.

8. The books prescribed to be read in connection with English composition are intended only to suggest the subjects in which the composition will be set; in the case of books prescribed under the head of literature, a special knowledge of the text will be expected.
The examiners have instructions to withhold marks in the cases of compositions which are irrelevant.

9. The honour course in the mathematical subjects will in every case include the pass course in the same Grade and subject.

PROGRAMME.

Preparatory Grade.

GREEK.

	Percentage of Marks
1. **XENOPHON**: Anabasis, Book I., omitting the speeches and chap. 9, with questions on grammar, &c., arising out of the text. (School text.)	40
2 Easy sentences for translation into Greek, the Greek for the more difficult words being supplied.	25
3. A passage or passages from some other Greek work or works for translation at sight, the meaning of the more difficult words being given.	20
4. Outlines (*i. e.* easy questions relating to the most remarkable events and personages, with dates) of Greek history down to B.C. 479.	15

LATIN.

1. (*a*) **CAESAR**: de Bello Gallico, Book I., chaps. 1 to 26 inclusive. (*b*) **OVID**: Fasti, Book II., lines 195 to 242, and Book IV., lines 809 to 852; **Tristia**, Book I., Eleg. 2, lines 19 to 56; and Eleg. 3, lines 1 to 26, and 79 to 102, with questions on grammar, scansion, &c., arising out of the texts.	40
2. Easy sentences for translation into Latin, the Latin for the more difficult words being supplied.	25
3. A passage or passages from some other Latin work or works for translation at sight.	20
4. Outlines (*i.e.*, easy questions relating to the most remarkable events and personages, with dates) of Roman History down to B.C. 241.	15

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE.	35

The following Ballads :—

- (*a*) **SCOTT**; Alice Brand.
- (*b*) **MACAULAY**: Battle of the Lake Regillus.
- (*c*) **BROWNING**: The Pied Piper of Hamelin.
- (*d*) **LONGFELLOW**: Robert of Sicily.

B—COMPOSITION.	65

Work to be read :—

KINGSLEY: The Heroes. (School text.)

HISTORY AND GEOGRAPHY.

	Percentage of Marks
1. History; outlines (*i.e.*, easy questions relating to the most remarkable events and personages, with dates) of the history of England and Ireland from the invasion of Britain by Julius Caesar to A.D. 1400; and outlines of the history of Europe in relation to that of England during this period. (The extent of knowledge of European history required will not exceed that to be found in Freeman's Primer, "Europe.")	70
2. Geography; the use of maps; size and shape of the earth; general outlines of the great divisions of the globe; outlines of the geography of Ireland.	30

FRENCH.

1. **XAVIER MARMIER**: **Le Protégé de Marie Antoinette, Première Partie** (school text); with questions on grammar, &c., arising out of the text.	30
2. A passage or passages from some other French work or works for translation at sight.	30
3. Easy sentences, colloquial phrases, and a short passage for translation from English into French, the French for the more difficult words being supplied.	40

GERMAN.

1. **GRIMM**: **Märchen—Hänsel and Gretel; Aschenputtel; Frau Holle; Rotkäppchen; Dornröschen**; with questions on grammar, &c., arising out of the text.	30
2. A passage or passages from some other German work or works, as well as a passage in German handwriting, for translation at sight.	30
3. Easy sentences, colloquial phrases, and a short passage for translation from English into German, the German for the more difficult words being supplied.	40

Students will not be required to write their answers in German handwriting.

IRISH.

1. (*a*) An Tarḃ Breac. (*b*) Sgeaċ Ṁic an Ċró.	30
2. A passage or passages from some other Irish author for translation at sight.	30
3. Easy sentences, colloquial phrases and a short passage for translation from English into Irish, the Irish for the more difficult words being supplied.	40

ITALIAN.

1. EDMONDO DE AMICIS: Cuore, *Ottobre, Novembre;* with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Italian work or works for translation at sight. 30

3. Easy sentences, colloquial phrases, and a short passage for translation from English into Italian, the Italian for the more difficult words being supplied. 40

SPANISH.

1. EDDY: Amigos y Auxiliares del Hombre, pages 1 to 76 (Ginn y Compañia); with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Spanish work or works for translation at sight. 30

3. Easy sentences, colloquial phrases, and a short passage for translation from English into Spanish, the Spanish for the more difficult words being supplied. 40

ARITHMETIC.

First four rules, simple and compound; reduction, including metric system; questions soluble by simple and compound proportion or by the unitary method; vulgar fractions; non-recurring decimals; calculation of rectangular areas and rectangular volumes.

GEOMETRY.

1. Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid, book I., propositions—i. to xli. inclusive, omitting ii, vii, xix, xxiv, xxv, xxix; book III., propositions i, iii, xi, xii, xvi, xx, xxi, xxii, and xxxi. Easy deductions. 70

2. Practical.—Constructions corresponding to the theoretical course, involving the use of graduated ruler, compass, and set square. 30

ALGEBRA.

Pass

Addition, subtraction, multiplication, and division of algebraic integers; simple equations in one unknown quantity; easy problems soluble by such equations.

Junior Grade.

GREEK.

Percentage of Marks

Pass

1. **XENOPHON**; Anabasis, Book I., omitting the speeches and chap. 9.
LUCIAN: Vera Historia, Book I. from Ὁρμηθεὶς γάρ ποτε ἀπὸ Ἡρακλείων στηλῶν to end (school text) with questions on grammar, &c., arising out of the texts. 80

2. Short sentences for translation from English into Greek, the Greek for the more difficult words being supplied. 30

3. A passage or passages from some other Greek work or works for translation at sight, the meaning of the more difficult words to be given. 30

4. Greek history down to B.C. 479. 10

Honours

1. More difficult sentences for translation into Greek; more difficult passages and questions on the pass course.

2. **EURIPIDES**: Troades, omitting the lyric portions; with questions on grammar, &c., arising out of the text.

A short passage of English verse for translation into Greek iambics.

LATIN.

Pass

1. (*a*) **CAESAR**: de Bello Gallico, Book I.
(*b*) **OVID**: Fasti, Book I., lines 539 to 582; Book II., lines 83 to 113 and 721 to 760; Book IV., lines 419 to 464, and 809 to 836, with questions on grammar, scansion, &c., arising out of the texts. 80

2. Short sentences for translation from English into Latin, the Latin for the more difficult words being supplied. 30

3. A passage or passages from some other Latin work or works for translation at sight. 30

4. Roman history from B.C. 241 to B.C. 133. 10

Percentage of Marks

Honours

1. More difficult sentences for translation into Latin; more difficult passages and questions on the pass course.

2. VIRGIL: Aeneid, Book VII., with questions on grammar, scansion, &c., arising out of the text.

A short passage of English verse for translation into Latin elegiacs or hexameters.

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE. 35

TENNYSON; Morte D'Arthur, commencing "So all day long" and ending "On the mere the wailing died away."
DICKENS: A Christmas Carol. (School text.)

B—COMPOSITION.

Work to be read:— 65

MARIA EDGEWORTH: Tales, viz.:—Murad the Unlucky; Lazy Lawrence; The False Key; The Lottery; The Barring-out; To-morrow; Simple Susan. (School text.)

HISTORY AND GEOGRAPHY.

Pass

1. Outlines (*i.e.* easy questions relating to the most remarkable events and personages, with dates) of the history of England and Ireland from A.D. 1400 to 1689. 70

2. Outlines of the Political Geography of the British Empire. 30

Honours

More difficult questions on the pass course in History, with special knowledge of the reign of Charles I.

Outlines of the History of Europe in relation to England during the reign of Charles I. (such as is given in Freeman's *Primer*).

More difficult questions on the Political Geography of the British Empire.

Percentage of Marks.

FRENCH.

Pass

1. **DAUDET**: Le Petit Chose en Province; première partie (school text); with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other French work or works for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into French 35

Honours

1. More difficult sentences for translation into French; more difficult passages and questions on the pass course.

2. **GRÉVILLE**: A la Campagne; (school text,) with questions on grammar, &c., arising out of the text.

GERMAN.

Pass

1. **GOEBEL**: Rübezahl; Der Herr des Riesengebirges; Wie der Name "Rübezahl" entstand; Der Schustergeselle; Die Studenten; Die Kräutersammlerin; Der Herzog von Ratibor; Der starke Drescher; Susi; Die beiden Leineweber; Der seltsame Gast; Der Glashändler; (school text), with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other German work or works, as well as a passage in German handwriting, for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into German. 35

Students will not be required to write their answers in German handwriting.

Honours

1. More difficult sentences for translation into German; more difficult passages and questions on the pass course.

2. **GOEBEL**: Rübezahl. The following in addition to the pass course: Der arme Heinz; Der Prager Musikant; Bauer Veit; Der Handwerksbureche; (school text), with questions on grammar, &c., arising out of the text.

Percentage of Marks.

IRISH.

Pass

1. Taḋg Gaba: with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Irish work or works for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into Irish. 35

Honours

1. More difficult sentences for translation into Irish; more difficult passages and questions on the pass course.

2. Poll an Ṗíobaire: with questions on grammar, &c., arising out of the text.

ITALIAN.

Pass

1. **EDMONDO DE AMICIS**: Cuore, *Ottobre*, *Novembre Dicembre*; with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Italian work or works for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into Italian. 35

Honours

1. More difficult sentences for translation into Italian; more difficult passages and questions on the pass course.

2. **METASTASIO**: Temistocle; with questions on grammar, &c., arising out of the text.

Percentage of Marks.

SPANISH.

Pass.

1. **MANTILLA**: Libro tercero de lectura; from page 1 to 52 inclusive, Hachette et Cie., with questions on grammar, &c., arising out of the text. 30

2. A passage or passages from some other Spanish work or works for translation at sight. 35

3. Short sentences, colloquial phrases, and a passage for translation from English into Spanish. 35

Honours.

1. More difficult sentences for translation into Spanish; more difficult passages and questions on the pass course.

2. **SAMANIEGO**: Fabulas; Books IV. and V., with questions on grammar, &c., arising out of the text.

BOOK-KEEPING.

Single and double entry; definitions of the terms used; form and purposes of the various books employed; recording of business transactions; posting, balancing, and closing the ledger; balance sheets; bills.

ARITHMETIC.

Preparatory Grade Course.

Practice; recurring decimals; percentages; averages; simple interest; square root; circumferences and areas of circles.

GEOMETRY.

Pass

1. Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid book I. book II., omitting propositions viii, ix, x, xi.; book III. as in the Preparatory Grade, together with propositions vii, viii, xiv, xv, xvii, xxvi (by superposition), xxxii, xxxiii, xxxv, and xxxvi. Easy deductions. 80

2. Practical.—Constructions corresponding to the theoretical course, involving the use of graduated ruler, compass, and set square. 20

Honours

The above theoretical course with more difficult deductions No practical part.)

ALGEBRA.

Pass

Preparatory Grade course. Evaluation of algebraic expressions and their graphical representation ; algebraic fractions ; simple equations involving two unknown quantities ; problems soluble by such equations.

Honours

Quadratic equations in a single unknown quantity; problems soluble by such equations ; indices; surds.

SHORTHAND

Dictation of short and simple sentences. Any system of shorthand may be used.

Middle Grade.

GREEK.

Pass

	Percentage of Marks
1. XENOPHON: Agesilaus. EURIPIDES: Troades, omitting lyric portions, with questions on grammar, &c., arising out of the texts.	30
2. Short passages from other Greek works for translation at sight.	30
3. English passages for translation into Greek.	30
4. Outlines of Greek history, from B.C. 479 to B.C. 399.	10

Honours

1. English passages for translation into Greek.	45
2. Passages from Greek authors for translation into English, with questions on grammar, &c., arising out of the passages. Standards for style and character of the passages. XENOPHON: Hellenica. EURIPIDES, omitting lyric portions.	40
3. Greek history, from B.C. 479 to B.C. 399.	15
4. A passage of English verse for translation into Greek iambics.	

LATIN.

Pass

1. CICERO: Pro Archia and pro Lege Manilia. VIRGIL: Aeneid, Book IX.; with questions on grammar, &c., arising out of the texts.	30
2. Short passages from other Latin works for translation at sight.	30
3. English passages for translation into Latin.	30
4. Outlines of Roman history, from B.C. 133 to B.C. 44.	10

Honours

1. English passages for translation into Latin.	45
2. Passages from Latin authors for translation into English, with questions on grammar, prosody &c., arising out of the passages. Standards for style and character of the passages. CICERO: Orations. VIRGIL: Aeneid.	40
3. Roman history, from B.C. 133 to B.C. 44.	15
4. A passage of English verse for translation into Latin elegiacs or hexameters.	

Percentage of Marks

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE

MACAULAY: Essay on Addison. (School text).

MILTON: L'Allegro line 37 to end.

GRAY: The Elegy written in a Country Churchyard.

GOLDSMITH: The Haunch of Venison.

BYRON: Childe Harold; Selections from Canto IV. :—The Gladiator, stanzas 139 to 141 inclusive; (*b*) The Address to the Ocean, stanzae 178 to 183 inclusive.

MOORE: Echo; I saw from the Beach; Oft in the Stilly Night;

LONGFELLOW; The Ladder of Saint Augustine. 35

B—COMPOSITION.

Work to be read :—

SCOTT: The Talisman. (School Text.) 65

HISTORY AND GEOGRAPHY.

Pass

1. The History of Great Britain and Ireland from 1689 to 1789. 70

2. Political Geography of Great Britain and Ireland in relation to the same period, together with outlines of the Political Geography of Europe at the present time. 30

Honours

More difficult questions on the pass course in History, together with epecial knowledge of the reign of Anne, and general history in relation to it.

Political Geography in general in relation to the reign of Anne, together with ontlines of the Political Geography of Europe at the present time.

FRENCH.

Pass

1. **XAVIER DE MAISTRE**: Un Voyage autour de ma chambre.
MOINAUX: Les deux Sourds. 30
with questione on grammar, &c., arising out of the texte.

2. Short passages from other French works for translation at sight. 35

3. Colloquial phrases and a passage of English for translation into French. 35

Honours

1. Passages from French authors for translation into English with questions on grammar, &c., arising out of the passages. 50

Standards for etyle and character of the passages. } **XAVIER DE MAISTRE.**
COPPÉE.

2. Colloquial phrases, and a passage of English for translation into French. 50

Percentage of Marks

GERMAN.

Pass

1. RIEHL : Kulturgeschichtliche Novellen ; viz. :—
Der stumme Ratsherr. Der Dachs auf Lichtmess.
UHLAND : Balladen und Romanzen, viz.:—
Siegfrieds Schwert ; Der gute Kamerad ; Des Knaben Berglied ; Schwäbische Kunde ; Klein Roland ; Roland Schildträger ; König Karls Meerfahrt ; Taillefer ; Das Glück von Edenhall ; Des Sängers Fluch ; Der blinde König (school text). 30

2. Short passages from other German works for translation at sight. 35
Students will not be required to write their answers in German handwriting.

3. Colloquial phrases and passage of English for translation into German. 35

Honours

1. Passages from German authors for translation into English, with questions on grammar, &c., arising out of the passages. 50

Standards for style and character of the passages. { RIEHL. UHLAND: Balladen und Romanzen.

2. Colloquial phrases, and passage of English for translation into German. 50
Students will not be required to write their answers in German handwriting.

IRISH.

Pass

1. (*a*) Trí Sgéalta.
(*b*) **HYDE**: Selections from Raftery's Poems ; viz. :—
1. Caoineaḋ ar Ṫomás O'Dálaiġ. 2. Béal-áta-na-haibne. 3. Anaċ Cuain. 4. Caismirt an Ṗótaire. 5. An Ḟiġeadóir. 6. Bainfeis an tSleaḋtáin ṁóir. 7. Seanċus na Sgeiṫe to quatrain 78 ; 30
with questions on grammar, prosody, &c., arising out of the texts.

2. Short passages from other Irish works for translation at sight. 35

3. Colloquial phrases and a passage of English for translation into Irish. 35

Honours

1. Colloquial phrases and a passage of English for translation into Irish. 50

2. Passages from Irish works for translation into English, with questions on grammar, prosody, &c., arising out of the passages. 50

Standard for style and character of the passages. { Sgríbne Gaeḋilge an Aṫar Peadar Ua Laoġaire.

ITALIAN.

Pass

1. FUCINI: All 'Aria Aperta (Ed. Bemporad, Florence)
TASSO: Gerusalemme Liberata, Cantos IV. and V., 30
with questions on grammar, &c., arising out of the texts.

2. Short passages from other Italian works for translation at sight. 35

3. Colloquial phrases and passage of English for translation into Italian. 35

Honours

I. Passages from Italian authors for translation into English, with questions on grammar, &c., arising out of the passages. 50

Standards for style and character of the passages. MACHIAVELLI; Historie Florentine. TASSO.

2. Colloquial phrases, and passage of English for translation into Italian. 50

SPANISH.

Pass

1. QUINTANA: Vida de Fr. Bartolomé de las Casas.
CERVANTES: Episodes from Don Quixote—"The Adventure of the Wooden Horse," and "Sancho Panza's Governorship" (school text); 30
with questions on grammar, &c., arising out of the texts.

2. Short passages from other Spanish works for translation at sight. 35

3. Colloquial phrases and passage of English for translation into Spanish. 35

Honours

1. Passages from Spanish authors for translation into English, with questions on grammar, &c., arising out of the passages. 50

Standards for style and character of the passages. QUINTANA. CERVANTES.

2. Colloquial phrases, and passage of English for translation into Spanish. 50

BOOK-KEEPING.

Junior Grade course extended to include;—stocktaking; provision for bad and doubtful debts; correction of errors; adjustment entries; partnership transactions; dealings in stocks and shares; transactions in connection with exports and imports.

ARITHMETIC.

Junior Grade course. Compound interest; profit and loss; stocks and shares; present worth and discount; use of logarithms.

Students are liable to questions requiring for their solution a knowledge of the metric system of weights and measures.

GEOMETRY.

Pass

1. Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid, books I., II. III., and IV.; easy deductions. 80

2. Practical.—Constructions corresponding to the theoretical course, involving the use of graduated ruler, compass, and set square. 20

Honours

The above theoretical course together with Euclid, book VI., the definitions of book V., and harder deductions. (No practical part).

Students may be required to give algebraical proofs of those properties of proportional magnitudes on which the establishment of the propositions of Euclid, book VI. depends.

ALGEBRA.

Pass

Junior Grade Pass course; simple equations involving two or more unknown quantities; quadratic equations in a single unknown quantity; problems soluble by such equations; indices; surds.

Honours

Junior Grade Honour course; theory of the quadratic equation; imaginary quantities; arithmetical and geometrical progressions.

TRIGONOMETRY.

Pass

General definitions of the trigonometrical functions; elementary identities; determination of the numerical values of the trigonometrical functions of 30° and 45° and their multiples; solution of right-angled triangles; rule of sines, formula for the cosine of an angle of a triangle, and easy questions on the solution of triangles dependent thereon.

Honours

Harder questions on the pass course.

SHORTHAND.

Dictation. Any system of shorthand may be used.

NATURAL PHILOSOPHY.

The measurement of length, area, and volume. Calculation of the area of simple figures and the volume of regular bodies.

The comparison of forces by the use of spring balances and elastic strings. The composition and resolution of forces in one plane by the principles of the parallelogram and triangle of forces.

The principle of moments with applications to levers. The balance. Mass. Weight and density. Centre of gravity, and simple cases of equilibrium. The action of friction in maintaining equilibrium. Stable, unstable, and neutral equilibrium.

Motion in a straight line with uniform velocity and with uniform acceleration. The momentum and energy of a moving body. The laws of motion and the measurements of force. Work. Potential energy. Elementary treatment of motion in a circle. The pendulum.

Pressure at a point in a fluid. Thrust on a plane area immersed in a fluid.

The principle of Archimedes. Specific gravity. Hydrometers. Simple hydraulic apparatus.

The pressure of gas. Boyle's Law. The barometer. The pump and other simple pneumatic apparatus.

Senior Grade.

GREEK.

Percentage of Marks.

Pass

1. A passage or passages of English prose to be translated into Greek. 45

2. Passages from Greek authors for translation into English, with questions on grammar, &c., arising out of the passages. 40

Standards for style and character of passage.
1. THUCYDIDES, the narrative portions; DEMOSTHENES, public orations.
2. HOMER.

3. Greek history, from B.C. 445 to B.C. 336 and outlines of Greek poetic literature and art within that period. 15

Honours

More difficult passages and questions on the pass course.

A passage of English verse for translation into Greek iambics.

LATIN.

Pass

1. A passage or passages of English prose to be translated into Latin. 45

2. Passages from Latin authors for translation into English, with questions on grammar, &c., arising out of the passages. 40

Standards for style and character of the passages.
1. LIVY.
2. HORACE. OVID: Metamorphoses.

3. Roman history, from B.C. 44 to A.D. 40, and outlines of Roman poetic literature and art within that period. 15

Honours

More difficult passages and questions on the pass course.

A passage of English verse for translation into Latin verse.

Percentage of Marks.

ENGLISH LITERATURE AND COMPOSITION.

A—LITERATURE.

SHAKESPEARE: Richard II. (School text.) 35

LAMB: Essays of Elia:—*viz.*;

Oxford in the Vacation; The Two Races of Men; New Year's Eve; Mrs. Battle's Opinions on Whist; All Fools' Day; Imperfect Sympathies; Witches and other Night Fears, The Praise of Chimney-Sweepers; A Dissertation on Roast Pig.

B—COMPOSITION.

Work to be read:— 65

SCOTT: Waverley. (School text.)

HISTORY AND GEOGRAPHY.

Pass

1. The history of Europe during the Revolutionary period—1789 to 1815. 70

2. Political Geography in relation to the same period, in addition to the outlines of the Political Geography at the present time of Asia, Africa and America, excluding British possessions. 30

Honours

More difficult questions on the pass course.

FRENCH

Pass

1. Passages from French authors for translation into English, with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages. { LAMARTINE.
ERCKMANN-CHATRIAN.

2. Colloquial phrases, and a passage of English prose for translation into French. 40

3. Outlines of the literary history of France in the 19th Century. 15

Honours

More difficult passages and questions on the pass course.

Percentage of Marks.

GERMAN.

Pass

1. Passages from German authors for translation into English with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages { FREYTAG. SCHILLER: Gedichte.

2. Colloquial phrases, and a passage of English prose for translation into German. 40

3. Outlines of the literary history of Germany from 1770 to 1830. 15

Students will not be required to write their answers in German handwriting.

Honours

More difficult passages and questions on the pass course.

IRISH.

Pass.

1. Colloquial phrases and a passage of English for translation into Irish. 45

2. Passages from Irish works for translation into English, with questions on grammar, prosody, &c., arising out of the passages. 40

Standards for style and character of the passages. { Bodaċ an Ċóta Laċtna. Aṁráin Ṗiarais Ṁic Ġearailt.

3. Outlines of the literary history of Ireland from the Norman Invasion to 1550. 15

Honours

More difficult passages and questions on the pass course.

ITALIAN.

Pass

1. Passages from Italian authors for translation into English with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages { MANZONI. ALFIERI.

2. Colloquial phrases, and a passage of English prose for translation into Italian. 40

3. Outlines of the literary history of Italy in the 18th and 19th Centuries. 15

Honours

More difficult passages and questions on the pass course.

Percentage of Marks

SPANISH.

1. Passages from Spanish authors for translation into English, with questions on grammar, &c., arising out of the passages. 45

Standards for style and character of the passages { MENDOZA. CALDERON.

2. Colloquial phrases, and a passage of English prose for translation into Spanish. 40.

3. Outlines of the literary history of Spain from the middle of the 16th century to the death of Calderon. 15.

Honours

More difficult passages and questions on the pass course.

BOOK-KEEPING.

The Middle Grade course, and in addition an elementary knowledge of the following subjects:—auditing; accounts of bankrupts, executors and trustees; bookkeeping and liquidation limited liability companies; the tabular method; and banking with special reference to the function and administration of the Bank of England.

ARITHMETIC.

Arithmetic in all its branches; mensuration of the cylinder, pyramid, cone, and sphere.

GEOMETRY.

Pass

(1) Theoretical.—An amount of knowledge will be expected approximately equivalent to that contained in Euclid, books I., II., III., IV., VI., with definitions of book V.—easy deductions. 90

(2) Practical.—Constructions corresponding to the theoretical course involving the use of graduated ruler, compass, and set square. 10

Honours

The above theoretical course, together with Euclid, book XI., propositions i. to xxi. inclusive—harder deductions. (No practical part.)

ALGEBRA.

Pass

Middle Grade Pass course in algebra. Arithmetical and geometrical progressions.

Honours

Middle Grade Honour course; permutations; combinations; binomial theorem and applications; elimination; simultaneous quadratic equations, and equations reducible to such, and questions leading to them; exponential and logarithmic series.

TRIGONOMETRY.

Pass

Trigonometry up to and including the solution of plane triangles; simple cases of inverse functions; properties of circumscribed, inscribed, and escribed circles of a triangle.

Honours

Harder questions on the pass course.

SHORTHAND.

Dictation. Any system of shorthand may be used

NATURAL PHILOSOPHY.

Same course as in Middle Grade.

Programme for Music.

The editions referred to in this Programme are for purposes of identification—no special edition is prescribed.

PREPARATORY GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises, Book I, Nos. 4, 6, 7, 8, 12, 15, 17; 18, Preliminary 1st Form, for Clavier, *or* Schmitt: Preparatory Exercises, Nos. 10 to 33, for Piano.
	2 Scales	Major scales of C, G, F, D, A. Harmonic minor scales of A, E, D, B. Hands separate and together. Compass, 2 octaves.
	Arpeggios	Major common chords of C, G, F, D, A. Minor common chords of A, E, D, B in close position. Hands separate. Compass, 2 octaves.
	Pieces	(*a*) An easy sonatina by Steibelt, Enckhausen, Schmitt, or Reinecke; and (*b*) Two "Album Leaves" from Op. 101, Gurlitt.

or

VIOLIN.	1. Scales	Major and melodic minor scales of G, A, B flat. Compass, 2 octaves, detached.
	2. Arpeggios	Arpeggios of above scales. Compass, 2 octaves, detached.
	3. Studies	Two studies: any two studies from Hermann, *Violin School*, Part I. (Peters).
	4 Pieces	Two pieces: any two pieces from Dancla, *Petite Ecole de la Mélodie*, Book I., Op. 123 (Schott).

or

VIOLONCELLO.	1. Scales	The major scales of C, G, D, A, F, B flat. Compass, one octave, in first position. A whole bow for each note.
	2. Arpeggios	The major common chords of the above scales. Compass, one octave, in first position. A whole bow for each note.
	3 Studies	Two studies: Schrœder, *Die Ersten Violoncello-Uebungen*. Op. 31, No. 9, (Peters), and another of equal difficulty.
	4 Pieces	Two pieces: Goltermann, *Contentment*, Op. 118, No. 5 (Augener), and another of equal difficulty.

or

HARP.	1. Scales	Major scales of C, G, D, A, E, F, with hands separate and hands together, one octave apart. Compass, 2 octaves.
	2. Arpeggios	Arpeggios of above scales, with separate hands. Compass, 2 octaves.
	3. Studies	Two studies: Bochsa's *Pupil's Companion*, Book 2, No. 18 (Ashdown), and another of equal difficulty.
	4. Pieces	Two pieces: Bochsa's *Sequel. Prelude and Lessons*, No. 8 (Chappell), and another of equal difficulty.
	5. Reading at Sight	To play at sight a very easy exercise.
	6. Ear Test	From C (middle) as tonic, and G (2nd line treble) as tonic, to recognise and name the notes of major common chord above these notes.
	7. Harmony	A knowledge of triads, triads in a key. Normal 8-bar sentence. Cadences. Chord progressions. Selection of roots for the harmonization of a given 8-bar melody. (See *First Principles of Harmony*, by S. S. Myerscough, Part I., Sec. II. This work is not prescribed, but is mentioned as indicating the extent of knowledge required.)

JUNIOR GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises. Book I., Nos. 13, 15, 19, 25, 18 Preliminary, 2nd Form, for Clavier, *or* Schmitt: Preparatory Exercises, Nos. 34 to 64, for Piano.
	2. Scales	All the major scales. All the minor scales in harmonic form. Hands separate and together. Compass, 2 octaves.
	3. Arpeggios	All the major and minor common chords, in close position. Hands separate and together. Compass, 2 octaves.
	4. Studies	Two studies: Pauer, No. 1 in C of 24 *Studies* (Augener 8326), and another of equal difficulty.
	5. Pieces	Two pieces of Beethoven, Menuetto from Sonata in D, Op. 10, No. 3 (Peters), and another of equal difficulty.

or

VIOLIN.	1. Scales	Major and melodic minor scales of G, A, B flat, B. natural, C, D. Compass, 2 octaves, (*a*) detached, (*b*) slurred in eights.
	2. Arpeggios	Arpeggios of above scales. Compass, 2 octaves, detached.
	3. Studies	Two studies: any two studies from Hermann *Études Spéciales*, Part I. (Augener).
	4. Pieces	Two pieces: Bohm, *Sechs Vorspielstücke*, No. 5, Intermezzo (Lengnick), and another of equal difficulty.
	or	
VIOLONCELLO.	1. Scales	Major scales of D, A, F. Minor scales (harmonic form) of A, D, G. Compass, 2 octaves, (*a*) detached, (*b*) slurred in fours.
	2. Arpeggios	The major and minor common chords of the above scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in threes.
	3. Studies	Two studies: Schrœder, *Die Ersten Violoncello Uebungen*. Op. 31, No. 18 (Peters), and another of equal difficulty.
	4. Pieces	Two pieces: Burgmüller, No. 1 of *Three Nocturnes* (Augener), and another of equal difficulty.
	or	
HARP.	1. Scales	All the major scales, with hands separate and hands together, one octave apart. Compass, 2 octaves.
	2. Arpeggios	Arpeggios of major scales, with hands separate and hands together, one octave apart. Compass, 2 octaves.
	3. Studies	Two studies: Bochsa's *Pupil's Companion*. Book 2, No. 20 (Ashdown), and another of equal difficulty.
	4. Pieces	Two pieces: Alvar's *Romances*, Book 4, No. 20 (Hutchings and Romer), and another of equal difficulty.
	6. Reading at Sight	As in the Preparatory Grade, the exercise, however, being of a more advanced character.
	7. Ear Test	From C (middle) or G (2nd line treble) as tonics, to recognise and name any note within the major octave scale, above.
	8. Harmony	Preparatory Grade Course. In addition, the laws of part-writing. Inversion of triads. Figuring for triads and their inversions. (See *First Principles of Harmony*, Part I., Secs. II. and III.)

MIDDLE GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises. Book 1. Nos. 26, 29, 30, 37, 18 Preliminary, 5th Form, for Clavier, *or* Schmitt: Preparatory Exercises. Nos. 120 to 160, for Piano.
	2. Scales	All the major scales. All the minor scales in harmonic form. Chromatic scales beginning on any key-note. Hands separate and together. Compass, 3 octaves.
	3. Arpeggio	All the major and minor common chords in extended position. Hands separate and together. Compass, 3 octaves.
	4. Studies	Two studies: Heller, *Study in C*, op. 47, No. 1 (Augener, 6187), and another of equal difficulty.
	5. Pieces	Two pieces: Haydn, *Presto (Finale) from Sonata in G* (Peters, 713*a*, No. 10), and another of equal difficulty.

or

VIOLIN.	1. Scales	All major, harmonic, and melodic minor scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in eights.
	2. Arpeggio	Arpeggios of major and minor common chords. Compass, 2 octaves, (*a*) detached, (*b*) slurred in threes.
	3. Studies	Two studies: any two studies from Kreutzer, 40 Studies (Peters).
	4. Pieces	Two pieces: any two pieces from David, *Bunte Reihe* (Augener).

or

VIOLONCELLO.	1. Scales	Major scales of D, A, F, B flat. Minor scales (harmonic form) of A, G, C, E. Compass, 2 octaves, (*a*) detached, (*b*) slurred in fours.
	2. Arpeggios	The major and minor common chords of above scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in threes.
	3. Studies	Two studies: Dotzauer, *Forty Studies*, No. 3 (Augener), and another of equal difficulty.
	4. Pieces	Two pieces: Mendelssohn, *Romance sans Paroles* (Novello), and another of equal difficulty.

HARP.	1. Scales	Major and harmonic minor scales, with hands separate and hands together, one octave apart. Compass, 3 octaves.
	2. Arpeggios	Arpeggios of major and minor scales, with hands separate and hands together, one octave apart. Compass, 3 octaves.
	3. Studies	Two studies: Bochsa's *Pupil's Companion*, Book 3, No. 28 (Ashdown), and another of equal difficulty.
	4. Pieces	Two pieces: John Thomas, *The Tear* (Hutchings and Romer), and another of equal difficulty.
	6. Reading at Sight	An easy piece or song accompaniment (omit song accompaniment for violin and 'cello.)
	7. Ear Test	To recognise and name any note of chromatic scale, with middle C as tonic, within compass of octave above or below.
	8. Harmony	Junior Grade course. In addition, the chord of the dominant 7th and its inversions, Cadential $^6_4$, passing $^6_4$. A given figured bass or 8-bar melody to test knowledge of the foregoing. (See *First Principles of Harmony*, Part I., Secs. II. to VII., inclusive.)

SENIOR GRADE.

PIANO AND CLAVIER.	1. Exercises	Virgil: Foundation Exercises, Nos. 174, 176, 177, for Clavier, *or* A third study, of the same difficulty as the piece prescribed as a study in 4 *infra* for Piano.
	2. Scales	All the major scales. All the minor scales in harmonic and melodic forms. Chromatic scales beginning on any key note. Hands separate and together. Compass, 4 octaves.
	3. Arpeggios	All the major and minor common chords and their inversions, in extended position. Hands separate and together. Compass, 4 octaves.
	4. Studies	Two studies: Bach, *Fugue in two parts in C minor* (Peters, 200, No. 3). and another of equal difficulty.
	5. Pieces	Two pieces, Beethoven, *Presto alla tedesca, from Sonata in G*, Op. 79, No. 25 (Peters), and another of equal difficulty.

or

VIOLIN.	1. Scales	All major, harmonic, and melodic minor scales. Scales of G, A flat, A natural, B flat, B natural in 3 octaves; all others, 2 octaves, (*a*) detached, (*b*) slurred in eights. Chromatic scales, beginning on any note. Compass, 2 octaves, slurred in eights.
	2. Arpeggios	Arpeggios of major and minor common chords, (*a*) detached, (*b*) slurred in sixes. Compass, 2 octaves.
	3. Studies	Two studies: Mazas, *Studies*, Book I., Op. 36 (Litollf), and another of equal difficulty.
	4. Pieces	Two pieces: Mozart, Adagio in E, (Augener, 7420), and another of equal difficulty.

or

VIOLONCELLO.	1. Scales	All the major scales. All the minor scales (harmonic form). Compass, 2 octaves, (*a*) detached, (*b*) slurred in eights.
	2. Arpeggios	The major and minor common chords of above scales. Compass, 2 octaves, (*a*) detached, (*b*) slurred in sixes.
	3. Studies	Two studies: Dotzauer, *Études*, Op. 107, No. 8 (Peters), and another of equal difficulty.
	4. Pieces	Two pieces: Marcello, Sonata in G minor, First movement (Augener), and another of equal difficulty.

or

HARP.	1. Scales	Major scales. Harmonic and melodic minor scales, with hands separate and hands together one octave apart. Compass, 3 octaves.
	2. Arpeggios	Arpeggios of major and minor common chords. Chords of the dominant and diminished 7th, with hands separate and hands together, one octave apart. Compass, 3 octaves.
	3. Studies	Two studies: Bochsa's *Forty Studies*, Book I., No. 6 (Chappell), and another of equal difficulty.
	4. Pieces	Two pieces: Handel, *Harmonious Blacksmith* (Hutchings and Romer), and another of equal difficulty.

6. Reading at Sight	A piece about as difficult as Junior Grade "pieces."

7. Ear Test	To recognise and name any interval within compass of an octave, between G below middle C of piano and G above the treble stave.
8. (*a*) Harmony	(*a*) Middle Grade course. Secondary 7th chords. Suspensions. Appoggiaturas, and auxiliary notes. A given figured bass, or a given 8-bar melody, to test knowledge of foregoing. (See *First Principles of Harmony*, Part I., and Secs. II. and III. of Part II.)
(*b*) Form	(*b*) Elements of Form, for Sonata.
(*c*) History of Music	(*c*) Sketch of the lives of eminent musicians, with knowledge of their influence on music.

The part of the Programme of the Department of Agriculture and Technical Instruction for Ireland entitled "*Programme of Experimental Science, Drawing, Manual Instruction, and Domestic Economy for Day Secondary Schools, Regulations and Syllabuses, Session* 1905-6," distinguished as XI., commencing on page 37 and ending on page 167 thereof, with the exception of the Syllabuses for the Auxiliary Course of Domestic Economy, commencing on page 147 and ending on page 149 thereof.

SYLLABUSES OF EXPERIMENTAL SCIENCE, DRAWING, AND DOMESTIC ECONOMY.

(1.)—PREFATORY NOTE.

Instruction in Experimental Science has now taken an important place as an element in a general education. In order to mantain its position it is not necessary that it should displace other branches of education no less important, which, indeed, it should supplement and subserve. To secure the full advantages which the study of Experimental Science has to confer, it is necessary to constantly keep in mind the purposes which such a course should serve. The principal functions of a well-designed course are—

(1.) The education of the power of observation, involving the exercise of judgment and the training of the senses.
(2.) The training of the reasoning powers.
(3.) The training of the executive powers. The experimental work performed by the pupils themselves involves the cultivation of manual dexterity, initiative, and self-reliance.
(4.) The imparting of some of the more important principles and facts of physical science.

For the realisation of these aims the course of instruction must be carefully planned and carefully taught. It will be seen that the method of teaching is regarded as being of greater importance than the mere imparting of knowledge, and that the best results of the training are not such as can be ascertained by a written test. A knowledge of the facts of science, however important, is secondary to the training in "scientific method" which the course is designed to confer. Not that the scientific method is a method peculiar to science; it is the same as that employed in business. In the investigation of scientific phenomena, however, the facts are more readily ascertainable, and the argument is free from those perturbing elements that enter into problems concerning human relationships.

What, then, is the scientific method? Enquiry into the history of the establishment of any great principle of physical science shows with more or less distinctness three distinct steps or processes:—

(1.) The collection and recording of observed facts.
(2.) The attempt to connect or explain the observed facts by framing a theory or hypothesis to account for them.
(3.) The attempt to establish the hypothesis by deducing a consequence arising from it and testing this by experiment.

The first two steps belong to induction. The third, which is deductive, was commonly employed in the middle ages until Bacon pointed out the importance of observation. The first step may obviously be taken by different individuals at various times. The second, implying a wide knowledge of the observed phenomena, involves the exercise of the highest reasoning power; experience has shown the danger of too little as well as too much theory. In the former case observations tend to become purposeless—in the latter, to introduce a preferential factor tending to vitiate the accuracy of the observations. The third step—verification—consists of two stages, (*a*) the deducing of a consequence of the hypothesis and (*b*) the testing of this by experiment.

When a hypothesis has thus been fully established it is termed a principle or a "law of Nature"—a somewhat unfortunate term since a "law of Nature" is nothing but a generalisation—a statement of an observed uniformity in the relations of phenomena—and is liable to revision as soon as wider knowledge may reveal an exception to the generalisation.

The history of science abounds in illustrations of the application of "scientific method." The discovery of the laws of planetary motion, the laws of gravitation, the planet Neptune, and the constitution of our atmosphere, are instances.

A course of instruction in science which neglects the enormous educative importance of a training in the scientific method loses the larger portion of its educational value. The mere acquisition of the facts of science—assuming it possible to convey them without practical work—must be regarded as quite secondary in value to the mental training and discipline involved by following out a few simple lines of investigation involving the exercise of the observing and reasoning faculties. This method, which has been called the "research" or "heuristic" method, involves the exercise of the highest powers of a teacher. It is less a method than a guiding principle. It requires that he should do less for his pupil than was common where a knowledge of facts was the sole aim, but the little required must be intensely purposeful. In fact, the teacher should avoid telling his pupils anything which they may fairly be expected to find out for themselves, and one of his highest functions is that of bringing clearly home to them the nature of the problem to be solved and the method by which it may be investigated. In certain cases it may be found desirable to establish a fact by the method of verification.

The full curriculum of instruction laid down in the following syllabuses consist of a two years' Preliminary Course followed by a two years' Special Course. The Preliminary Courses deal with fundamental principles, and, in addition to providing exercises in observational work, principally weighing and measuring, afford ample opportunity for the study of experimental methods. While the same method should inspire the work of the third and fourth year courses, and while the course should be strictly experimental, more attention may be paid to theory, and the student may now be referred to the observations of others. Text-books may now with advantage be used, and the student will be in a position to appreciate the results obtained by experienced workers in the field of science. The Special Course should, as far as possible, be selected with a view to the future possible career of the student.

Preliminary Course.

A study of the first and second year syllabuses will show that the work is mainly observational in character, and deals largely with weighing and measuring. Great attention should therefore be attached to accuracy. If a sufficiently high standard be held before them and suitable instruction in manipulation be given, yonng students are able to attain a considerable degree of accuracy in weighing and measuring. They should be expected to obtain results fairly within the limits rendered possible by their apparatus, the due care of which forms an important part of their training. That portion of the syllabus which deals with Mensuration is regarded as important, but the amount of time to be devoted to it will to some extent depend upon the pupils' previous knowledge.

It will be found of considerable advantage to keep the class together as far as possible, so that the teaching may be "collective." At the end of each practical lesson the results obtained should be collated and discussed, and a general conclusion drawn. It would be difficult to over-estimate the value of this portion of the lesson, which should include oral questions requiring clearly-expressed replies. When the results are tabulated and widely erroneous ones rejected, and the cause of the errors explained, the value of a "mean" result can be brought home. A word may here be said about arithmetical results. These frequently pretend to an impossible degree of accuracy. It is misleading and uselessly wearisome to carry a calculation further than the accuracy of the factors warrants. The importance of standards of length and mass should be made clear and the legal standards carefully described. The exercises in Mensuration should not be confined to small objects. The areas of the floor of the class-room, the top of the bench, the playground (measured with a tape or chain) should be varied with the smaller objects in use in the laboratory. The volume of a water tank or cylinder, the weight of a mass of masonry (calculated from volume and density), and such like exercises, will impress upon the young pupil the practical aim of his laboratory work. The measurements should be made both in English and Metric units.

Great importance is attached to the pupils' records of laboratory work. They form a permanent record of the pupil's own work, and should as far as possible be expressed in his own words, though the form in which they are to be made will necessarily be a matter for careful direction. Without running the risk of stereotyping what should to some extent give scope for initiative, the following suggestions respecting these records may be made:—

(*a*.) The note-books should be large, of uniform size, and should contain pages of squared paper for "graphs."

(*b*.) A statement of the object of the exercise should precede a terse description of the method of performing it, and this should be illustrated by simple *diagrammatic* sketches of the *essential* parts of the apparatus employed. These sketches take the place of wordy descriptions.

(*c*.) The results obtained should be entered up at once, in ink. The recording of observed measurements on scraps of paper until it is ascertained by calculation how far they accord with an anticipated result, is to be deprecated. The observation is likely to be more carefully made if it be regarded as unalterable.

(*d*.) The observations should be honestly recorded, no matter how far the result may differ from the result expected. Any attempt to "adjust" observed measurements to an expected result should be treated as a serious defect.

The source of a serious error subsequently ascertained may be recorded in a footnote—it will have a definite educational value.

(*e*.) The records should state shortly the inferences drawn from the observations.

(*f*.) The records should be revised. An inconclusive exercise, or one in which the result is very wide of the truth, should never be allowed to pass without an explanation of the cause of failure.

(*g*.) All exercises should be dated.

Attention may be drawn to the curving of results, to express the relation between two varying quantities. Facts not readily gathered from a table of figures become obvious from a curve.

The following are a few only of the results in the first year course which may be so treated:—

English and Metric units of length;
Circumference and diameter of circles;
Diameter and volume of spheres.
Length and period of swing of pendulum;
Extension and pulling force of a spring;
Pressure and volume of a mass of gas;
Density and temperature of water near freezing point;
Fahrenheit and Centigrade thermometric scales.

In order to obtain the greatest value from the course, every pupil should work practically through the exercises involved. This precludes working the pupils in groups, and only where it is impossible to arrange otherwise should they be allowed to work in pairs. It is invariably found that one of the pair does the work and the other loses the full value of the training. There are probably a few exercises in the course where a careful demonstration by the teacher might usefully replace work by the student, as *e.g.*, the composition of water by synthesis. The cases are few, however, and the notes of them should indicate that the results obtained were not the work of the pupil.

In a scheme where mental training is regarded as the main thing to be aimed at and the mere knowledge of facts as subordinate, the logical treatment of the course should always command the consideration of the teacher, and the exercises should be devised with this end in view. For example, suppose the subject in hand is that of specific gravity. The pupil has already found that substances differ in density, and has found the weight of one cubic centimetre of various solids and liquids. Nothing, however, has been done to suggest to him the principle of Archimedes.

How may he be led to find it out? A course such as the following suggests itself:—

Take a mass of some substance, say iron, and immerse in a vessel quite full of water. The displaced water, which is equal in volume to the mass of iron, is carefully collected and weighed. The mass of iron is now weighed in air and in water. The loss of weight in water is at once seen to be equal to the weight of the water displaced, *i.e.*, to that of a volume of water equal to the iron. If the experiment be repeated with different solids and liquids the principle of Archimedes is arrived at without difficulty.

Other parts of the syllabus, as *e.g.*, the study of the composition of air, the rusting of metals, etc., offer excellent opportunities for the study of scientific method.

The Preliminary Course includes drawing of a simple character. At this stage drawing cannot be regarded as much more than an extension of writing—its object being a means of expression. Every effort should be made to co-ordinate it with the teaching of science, and examples for memory and object drawing should, where possible, be chosen from the laboratory.

Special Courses.

The full course now provides syllabuses for special courses of instruction in—

Physics,
Chemistry,
Mechanical Science,
Botany,
Physiology and Hygiene,
Geology,
Domestic Economy,
Drawing.

It is hoped that schools will exercise a wise discretion in the choice allowed in regard to the special courses, and that they will be selected with a view to local needs. In the case of girls' schools especially, attention is drawn to the courses in Domestic Economy and Physiology and Hygiene.

General remarks on method of treatment accompany the special course syllabuses. In these courses the thoughtful teacher will form his own methods, but they should be inspired by the principles which underlie the treatment of the preliminary courses. In these it will be found possible to apply the historical method with advantage, and teachers are advised to study carefully the history of the branch of science with which they are dealing.

At the conclusion of the full course the student should not only have an intelligent grasp of the elementary principles of science, but he should have gained something of the true spirit of scientific enquiry. This cannot fail to beget an appreciation of the limitations of his own knowledge, and an attitude of reverence in regard to the wide unexplored tract in the region of science.

(2.)—PRELIMINARY COURSE OF EXPERIMENTAL SCIENCE AND DRAWING.

(*a*.)—EXPERIMENTAL SCIENCE.

FIRST YEAR SYLLABUS.

1. *Measurement of Length.*—English and metric measures of length; comparison of one system with the other by actual measurements. Standards of length. Measurements of lengths of straight and curved lines. Use of parallel blocks: calipers. Determination of ratio of circumference of circle to diameter. Use of micrometer and vernier.

2. *Measurement of Area.*—Units of area. Reasons for expression of areas as squares. Direct methods of determining the areas of regular figures: by actual division into square cms., the fractions being estimated at sight; by means of squared paper; and by measurement of linear dimensions. Indirect methods of determining areas. Use of cardboard or other material in the determination of areas. Area of circle, deduced from the relation between the weight of a circle of cardboard and the weight of a square of the

same cardboard of side equal to the radius of the circle; and in other ways. Indirect methods of determining ratio of circumference of circle to diameter. Verification of some of the propositions of Euclid, as *e.g.*, I., 47.

3. *Measurement of Volume.*—Units of volume. Reasons for expression of volumes as cubes. Direct calculation of the volumes of regular solids from measurements of their linear dimensions. Use of fluid measures: burette, pipette, graduated cylinders, &c. Indirect measurement of volume.

4. *Measurement of Mass and Weight.*—Units and Standards. Distinction between mass and weight. Experiments on the extension of a spring or rubber cord by various weights. Equilibrium of a lever with two or more weights. Principle of moments. Use of lever to determine an unknown weight. Principle of the balance. Definition of centre of gravity. Determination of the centre of gravity of laminæ of various shapes.

5. *Measurement of Density.*—From measurements of volume and weight find the weight of one c.c. of various solids and liquids. Weight of one c.c. of water. Definition of density. Density of liquids determined by means of (1) burette and balance; and (2) bottle. Beginning with the observation that a brick appears to lose weight when immersed in water, carry out a series of experiments with solids of various sizes and with different liquids, in order to bring out that the apparent loss of weight depends on the volume of the solid and on the density of the liquid used, thus leading up to a statement of the principle of Archimedes. Use of this principle to determine volume and density of solids, and density of liquids. Extension of the principle to substances lighter than water, thus leading to the law of floating bodies. Use of hydrometers in determining densities.

6. *Fluid Pressure.*—The foregoing experiments having shown that liquids are capable of exerting an upward pressure or thrust on bodies immersed in them, further experiments may be carried out to bring out more fully the laws of fluid pressure; these should include experiments with U and inverted Y tubes possessing limbs of equal and unequal bore (incidentally the densities of liquids may be determined by measuring balancing columns) and the measurement of pressures of gases by the lengths of columns of liquids which they can support.

7. *Barometer.*—The pressure of the atmosphere and the weight of a known volume of it should receive consideration at this stage; and this would lead to the construction of the barometer. Reading of barometer; standard barometer. Effect of introducing air, water, etc., above the barometric column. Determination of the weight of one litre of air, under conditions existing in room by expelling air from a flask.

8. *Boyle's Law.*—Investigation of the relation between the pressure and the volume of a gas at constant temperature. Curves exhibiting the relations between P. and V., between P. and $\frac{1}{V}$, or $\frac{1}{P}$ and V.

9. *Measurement of Time.*—At this stage should follow some exercises on the pendulum in order that the pupils may understand the principle of the pendulum as a time measurer, and also that they may be exercised in time measurements, such as are required for heat experiments. **Pendulum**: relation between the number of

vibrations in a given time and the length of the pendulum. Period of vibration independent of mass of "bob," and—within moderate limits—of the arc of swing.

10. *Heat*—Effect of increase of temperature on volume of given mass of solid, liquid, gas—qualitatively. Determine, as far as possible, whether expansion and contraction are regular or irregular. Expansion a means of determining *hotness* or temperature. The thermometer and its fixed points. Comparison of Centigrade and Fahrenheit thermometers. Coefficients of expansion—gas, solid, liquid—using dilatometer tube only and *not* weight thermometer. Conductivity and comparison of conductivities by simple methods.

SECOND YEAR SYLLABUS.

The exact starting point of the Second Year's work will depend on the extent of that done in the First Year. But the second year must be mainly devoted to work of the character outlined below.

1. Laboratory work should begin with the observation of the apparent differences (form, colour, &c.) of some common and some laboratory substances, such as sand, soda, salt, alum, nitre, blue vitriol, green vitriol, salammoniac, sulphur, sugar, wood. The effect of heating these substances, and of hot and of cold water on them, should be tried; their behaviour towards litmus and turmeric should be ascertained. In this way much will be learned about distillation, evaporation, solution, crystallisation and filtration.

2. *Fuller Study of Solution.*—The observation having been made that many substances are more soluble in hot than in cold water, the solubility of such substances as salt and saltpetre should be found at the laboratory temperature, and say at 50°C. Solubility curves should be obtained later in the course when the pupils are more skilful in manipulation.

3. *Study of the rusting of Iron.*—It is a matter of common knowledge that a clean iron surface when exposed to moist air becomes dull: the examination of this change forms an interesting study. Comparison of bright iron with rusted iron to bring out qualitatively the physical differences. What are the conditions of rusting? will iron rust in dry air? in water free from air? in moist air? Recall the experiments on density and determine the density of iron and of iron rust. Weigh a quantity of iron filings; rust, weigh again. How may the difference in density, and the increase of weight be accounted for? Allow iron to rust in air enclosed over water; examine from day to day; test residual air to bring out alteration in volume and in properties. Existence of two constituents in air; an active and an inactive. Substances such as phosphorus, candle, spirit, and sulphur, which burn easily in air, should be burned in confined volumes of air, and the products of combustion, as well as the residual air, carefully examined—quantitatively, whenever possible.

4. *Action of Heat on Metals.*—Attention should be directed to the formation of smithy scale on iron when heated; and experiments should be carried out with iron and other metals to ascertain, first qualitatively, and then quantitatively, what changes occur when they are heated. The similarity between the formation of the metallic calces and iron rust will thus be brought out.

5. *Further study of the active constituent of Air.*—The various metalic calces or rusts should be heated to find out whether they will give up the active air which they contain. Mercury calx and

red lead will be found to give off a gas in which a glowing match bursts into flame, which will be wholly absorbed by moist iron filings, and which, when mixed with four times its volume of inactive air, forms a mixture possessing the same properties as air. It may thus be concluded that active air has been obtained. In order to save time and expense, prepare large quantities of the gas from chlorate of potash or permanganate of potash. Study the properties of the gas; the name "oxygen"; definition of an oxide; theory of combustion.

6. *Preparation of the common acids and alkalies.*—In heating green vitriol it will have been observed that acid fumes are evolved, and in this manner the production of oil of vitriol may be introduced. By the action of this substance on nitre and rock-salt the other two common acids should be prepared. Qualitative study of caustic soda, caustic potash, and ammonia may follow. Preparation of salts by careful neutralisation of these alkalies would now form very useful exercises.

7. *Study of Chalk.*—Chalk was early a subject of chemical research; and much may be learnt from a study of it. Note its obvious properties, and then the effect of heating it. Differences between chalk and lime in their behaviour towards water and litmus. Quantitative study of the change effected in chalk by strongly heating it—loss of 44 per cent. Collection of the gas and study of its properties; behaviour towards litmus and lime water. Action of acids on lime and chalk qualitatively and quantitatively. Collection of gas from acid and chalk; identity with that produced by heating chalk. Measurement of volume and weight of gas obtained in this way from one gramme of chalk; compare numbers with those obtained from heating one gramme of chalk. Burn magnesium in the gas; presence of carbon and oxygen suggested. Burn carbon in oxygen; shake up residue with lime water; identity established between gas obtained from chalk and that produced on burning carbon in oxygen. Hard and soft water. Synthesis of chalk. Presence of carbonic acid gas in air. Action of acid on carbonates, such as washing soda, etc.

8. *Action of Acids on Metals.*—Try the action of acids on lead, zinc, copper, tin, magnesium, iron, aluminium, &c. It will be observed that in many cases an inflammable gas is evolved; collect the gas and examine its properties. Burn the gas in air, collect the product and indentify it. The name "hydrogen." Reduction of oxides by hydrogen. Study of water.

9. These exercises afford much scope for the use of the balance. For example, in determining the properties of oxygen the weight and volume of the gas evolved on heating a certain quantity of potassium chlorate should be ascertained, and hence the weight of a litre of oxygen under (*a*) laboratory, and (*b*) N.T.P. conditions should be found. The number so determined should be compared with that previously found for air and checked by comparing the weights of oxygen and air held by a flask of known volume. Similarly the weight of a litre of carbonic acid gas should be determined. In the case of hydrogen the weight of one litre of the gas may be assumed. Such exercises as finding the volume at N.T.P. of hydrogen displaced from (*a*) dilute sulphuric acid by one gramme of zinc, (*b*) dilute sulphuric acid by one gramme of magnesium, (*c*) dilute hydrochloric acid by one gramme of aluminium, etc., etc., should be undertaken, and the weights of metals required to displace one gramme of hydrogen should be

calculated. From these and other quantitative exercises evidence will gradually be accumulated to bring home to the student's mind some of the fundamental generalisations, such as the indestructability of matter, the law of constant composition, and the notion of equivalent weights. In all the quantitative work class results should be collected, and after being fully discussed should be neatly tabulated in the note-books.

No attempt should be made to teach the Atomic theory, to write formulæ, or to give equations for reactions. The Course is intended to be an experimental one; but exercises in classification will arise under such headings as elements, compounds, oxides, carbonates, acids, alkalies, and so on.

The pupil will now be in a position to take up the study of one or more of the main branches of Physical or Natural Science. It is intended that the work of the third year should be devoted to at least one such branch, and that of the fourth to another.

(b.)—DRAWING.

FIRST YEAR SYLLABUS.

Elementary Freehand Drawing, with the addition of simple exercises in Design. Drawing of Objects in outline: pupils, who are qualified, should draw from real objects. Memory Drawing.

SECOND YEAR SYLLABUS.

Elementary Freehand Drawing, with the addition of simple exercises in Design. Drawing of Single Models and Real Objects in outline. Memory Drawing.

PRACTICAL GEOMETRY.—The instruction may be limited to problems involving simple constructions in the following:—

(1.) Constructions required in geometrical pattern drawing, simple tracery, and mouldings.

(2.) Construction of regular polygons—general method. Inscribed and circumscribed circles. Simple cases of rectilinear figures described in or about other rectilinear figures.

(3.) Circles—passing through three points—touching three lines. Tangent lines and circles to one or two circles.

(4.) The construction and measurement of angles. The construction of triangles from given data.

(5.) Construction of irregular polygons from given sides, angles, and diagonals. Similar figures—equal, enlarged, or reduced.

(6.) Construction of plain scales and scale of chords. Proportional division of lines, including the mean, third, and fourth proportionals. Reduction of polygons to triangles of equal area. Construction of parallelogram or square equal to a given triangle or other rectilinear figure.

PRELIMINARY COURSE OF EXPERIMENTAL SCIENCE.

SUGGESTED LISTS OF APPARATUS AND MATERIALS.

FIRST YEAR.

A.

(Apparatus required for each pair of Students.)

One half-metre scale, graduated in cms. and mms., and in inches and tenths.
One pair scissors.
One pair compasses.
Two set squares.
One retort stand (base 9 inches by 6 inches, height 2 feet), with three rings and clamp, to hold tubes up to diameter 1¼ inches.
One balance, to carry 250 grms., sensitive to 2 mgms.
One box weights, 200—·001 grm. (cheap).
Two beakers, 3 inches high (medium form).
Two beakers, 4½ inches high (medium form).
One N.M. stoppered bottle, with narrow top stopper, 2 oz., or S.G. bottle 50 grammes.
Two iron tripods.
Two squares wire gauze, 30 mesh, 5 inches by 5 inches.
Two sand baths.
*Two Bunsens, No. 2 size.
*Two yards black rubber tubing for the Bunsens.
Two small flasks, 2 ozs.
Two rubber corks, 1 hole, (No. 4 size).
Two flasks, 12 ozs.
One specific gravity bridge.
One pestle and mortar (Wedgwood 3½-inch diam.)
One 50 cc. burette.
One single burette stand and clamp.

B.

(Apparatus required for each group of four Students.)

One metre scale, graduated in cms. and mms., and in inches and tenths.
Three rectangular wooden blocks, 2 inches by 2 inches by 4 inches.
One pair inside and outside calipers.
One set (8) 2 cm. cubes of various woods.
One 4 cm. cube of ebony.
One 1 in. cube of ebony.
One 25 cc. pipette.
One 100 cc. graduated cylinder.
One 250 cc. ,, ,,
One pyramid (base an equilateral triangle of side, 2½ cms.; height, 5 cms.)
One prism (base an equilateral triangle of side, 2½ cms.; height, 5 cms.)
One cylinder (diameter of base, 3 cms.; height, 3 cms.)
One cone (diameter of base, 3 cms.; height, 3 cms.)
One sphere (diameter, 3 cms.)

These should be accurately made of box-wood or brass, preferably the latter.

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* See note, page 82.

One bell jar and stopper, 9 inches by 4 inches.
One rubber cork, 1 hole, to fit the bell jar.
One triangular file.
One stout round-bottom flask, about 500 cc. capacity.
One rubber stopper, 1 hole, to fit this flask.
Two yards black rubber tubing, ⅛-inch.
One pinch cock (Mohr's), 2¼-inch.
One barometer tube.
One deal board, 36 inches by 4 inches by ½-inch.
One Boyle's law tube (unmounted).
One iron rod, 1 foot 6 inches long, 3-16th-inch thick.
One brass rod, ,, ,, ,, ,,
One thermometer, engraved on stem, graduated up to 120° C.
One thermometer, engraved on stem, graduated up to 50° C. in fifths of degrees.
One thermometer, engraved on stem, graduated up to 250° F.
One Liebig's condenser, 12-inch.
One funnel, 2½ inches diameter.
One spun copper inside calorimeter, 1½-inch diameter, 3 inches high.
One stout glass pneumatic trough, 10 inches by 4 inches.
One opisometer.
One common hydrometer.
One Nicholson's hydrometer (brass).
One large cylinder for use with the Nicholson's hydrometer.
One Hare's apparatus (mounted).
One U tube, limb 2 feet by ⅜-inch.
One stop watch (not to exceed 6*s.*)
One iron saucepan (one gallon).
One rat-tail file.
One small curved pipette to fit into barometer tubes.

C.

(*Apparatus and materials required for general use.*)

One demonstration balance, similar to balance in A, but with pointer both sides.
One model Vernier for demonstration purposes.
Two micrometer screw gauges (superior).
One sliding calliper, with vernier (superior).
One ream squared paper (good).
One hollow cubic decimetre.
Five dozen 1 cm. wooden cubes.
Regular and irregular lumps of various common metals for density determination.
One litre flask.
One ½ ,, ,,
One each pipettes (1, 5, 10, 20, 50, 100 cc.)
One 500 cc. graduated cylinder.
One brass bucket and cylinder for the Principle of Archimedes.
One steel tape measure.
One yard stick.
One specific gravity bottle and counterpoise.
One lactometer.
One doz. leaden spheres of various masses for pendulum experiments.
One cheap barometer (filled).

Four yards pressure tubing.
One Boyle's law tube on stand, with movable cistern.
One max. and min. thermometer (Fahrenheit).
One wet and dry bulb thermometer (Fahrenheit).
One Centigrade thermometer (mounted).
Half lb. thermometer tubing (1 mm. bore).
One paraffin, spirit, or benzene blow lamp.
Three rubber bellows as used with spray producers, for drying flasks, &c.
$\left.\begin{array}{l}\text{Three sets of cork borers (1-3)}\\ \text{One set of cork borers (1-10)}\end{array}\right\}$ Best quality.
Five lbs. glass tubing, sizes (1, 2, 3, 4).
Five yards rubber tubing, $\frac{1}{8}$-inch.
*Two batswing burners on stand 10 inches high.
*One Fletcher burner and one yard rubber tubing to fit.
One square of asbestos board, 1 foot by 1 foot.
Six dozen assorted wood corks.
Two dozen assorted rubber stoppers.
Six dozen test tubes, 5 inches by $\frac{5}{8}$-inch, and two dozen test tubes, various.
One reel very fine copper wire.
One lb. copper wire, various sizes, in long lengths.
One pair wire-cutting pliers.
Three empty Winchester quarts.
Three empty half Winchester quarts.
Six W.M. 16 oz. unstoppered bottles, fitted with corks;
One dozen test tube brushes.
Two test tube racks (10 holes).
Two dozen thermometer bulbs, with stem (1 mm bore)
Half lb. paraffin wax.
One lb. hyposulphite of soda.
Quarter lb. solid litmus.
One W.Q. methylated spirit.
One pint ether.
Half oz. magenta.
Ten lbs. mercury.
Two lbs. lead shot.
Four lbs. nitre.
Four lbs. sand.
Quarter lb. tin sheet.

SECOND YEAR.

APPARATUS REQUIRED IN A LABORATORY PROVIDED WITH THE FIRST YEAR'S APPARATUS AS DETAILED ABOVE.

D.

(Apparatus required for each pair of Students.)

One piece of platinum wire, 4 inches long.
One piece platinum foil, 2 inches by 1 inch.
Two crucibles and lids, No. 0.
One pair iron crucible tongs.
Two fire-clay triangles.

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* See note, page 82.

Two clock glasses, 4 inches.
Two watch glasses, 2 inches.
Four cylinders, 6 inches by 2 inches, ground on top, foot with rim.
Four ground glass plates.
One deflagrating spoon.
One small beehive shelf.
One retort, stoppered, 8 oz.
One 4 oz. W.M. unstoppered bottle.
One rubber cork, 1 hole, to fit.
Eight oz. N.M. bottles with flat stoppers, labelled Hydrochloric Acid Dilute, Sulphuric Acid Dilute, Nitric Acid Dilute, Ammonium Hydrate Dilute, and Distilled Water.
Eight oz. N.M. bottle with rubber cork, labelled Caustic Soda.
Four oz. N.M. bottles with glass stoppers, and sand-blasted or enamelled labels as follows:—Hydrochloric Acid Concentrated, Nitric Acid Concentrated, Sulphuric Acid Concentrated.
Eight oz. N. M. bottle, fitted with cork and pipette, and labelled Litmus Solution.
Two funnels, 3 inches diameter.
Two thistle funnels, 9 inches.
One bone spatula.
One filter stand.
One test tube rack and test tube brush.
One each, box of red and blue litmus paper.
*Two star supports and chimneys for No. 2 Bunsens.
One apparatus for carbonic acid determination (cheap form).
Two evaporating dishes (No. 2 size).
One Woulff's bottle, 12 ozs., 2 necks.
One length hard glass tube (No. 9) closed at one end, 2 feet 6 inches long.
One rubber stopper to fit.
One screw cock, bottom part with hinge, ¾-inch.
One calcium chloride tube, 4 inches, U form.
One porcelain boat, 2 inches.

E.

(Apparatus required for each group of four Students.)

One earthenware or stout glass pneumatic trough, 10 inches by 4 inches.
Two tubulated bottles, 32 ounces—one, with one hole rubber corks in both holes, and the other with one hole rubber cork at bottom only.
One iron tube, 1 foot long, ⅝-inch internal diameter, closed one end.
One paraffin or benzene blow lamp, upright form.
One pair salamander crucible jackets, with fire clay triangle to fit.
One bell-jar and stopper, 9 inches by four inches, with one-hole rubber stopper to fit.
One Liebig's condenser, 12 inches.

F.

(Apparatus and materials required for general use.)

*One Ramsay burner.
One gross small rectangular fire-clay dishes (Morgan & Co.).
One thousand filter papers (qualitative), 10 cms.

* See note, page 82.

One hundred filter papers (qualitative), 20 cms.
Two iron tubes, 9 inches by ½-inch (internal diameter), closed one end.
Five canes hard glass tube, No. 9 size.
Five lbs. glass tubing, sizes 1, 2, 3, 4.
Two lbs. glass rod, sizes 1 and 3.
Two gross test tubes, 5 inches by ⅝-inch.
Half gross test tubes, 2 inches by ½-inch.
Three dozen boiling tubes.
Half gross hard glass tubes, 6 inches by ¾-inch.
*One muffle furnace, space inside muffle, 3⅞ inches wide, 3 inches high, 6½ inches long.
*One pair tongs for muffle.
One drying oven, 9 inches by 9 inches.
Six beakers, 6 inches high.
Six evaporating dishes, 5 inches diameter.
One iron tube, 1 foot 6 inches long, ¾-inch internal diameter, open both ends.
Twenty sheets coarse filter paper.
Ten yards rubber tubing, ⅛-inch diameter.
One dozen No. 0 crucibles.
One dozen funnels, 3 inches diameter.
One dozen evaporating dishes, No. 2 size.
One dozen 12-oz. flasks.
One dozen 16-oz. flasks.
One dozen test-tube brushes.
One filter pump with flask, funnel, cork, and plate.
Two packets filter papers to fit.
Six thistle funnels, 9 inches.
One dozen nests of beakers (Nos. 1-3), medium form.
Three pestles and mortars, various sizes.
Two funnels, 4-inch diam.
*One foot bellows and blow-pipe.
One yard platinum wire.
Platinum foil, 4 inches by 4 inches.
Three retorts, 8 ozs., with stopper.
One lamp glass and bung.
Specimens of quartz, fluor spar, selenite hæmatite, calcite, china clay, bauxite, felspar, mica, galena, cinnabar, iron pyrites, tin-stone, copper ore, and native sulphur, in W.M. bottles.
Two lbs. alum.
Five lbs. iron turnings.
One lb. iron filings.
Two lbs. iron rust.
Quarter lb. yellow phosphorus.
Half lb. asbestos wool.
Four lbs. red lead (pure).
One lb. litharge (massicot), pure.
Two lbs. sulphur.
One lb. manganese dioxide.
Four lbs. potassium chlorate.
Two lbs. potassium permanganate.
Half lb. magnesium oxide.
One lb. zinc oxide.

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* See note, page 82.

Half lb. copper oxide (powder).
Half lb. mercuric oxide.
Five lbs. common salt.
Two lbs. copper sulphate.
One lb. green vitriol (commercial).
Three lbs. rock salt.
Two Winchester quarts hydrochloric acid (commercial)
Two Winchester quarts nitric acid (commercial).
Two Winchester quarts sulphuric acid (commercial)
One lb. caustic soda.
,, ,, potash.
Two Winchester quarts ammonium hydrate.
Two lbs. quick lime.
Three lbs ammonium chloride.
Five lbs. chalk.
Four lbs. marble.
One lb. carbon.
Five lbs. washing soda.
Half lb. magnesium carbonate (heavy).
One lb. copper ,, (pure).
One lb. lead ,, ,,
One lb. zinc ,, ,,
Half lb. zinc foil (pure).
Five lbs. zinc, granulated.
Two lbs. zinc sticks.
One lb. granulated tin.
Quarter lb. aluminium foil.
Quarter lb. magnesium ribbon.
Two lbs. copper turnings.
Quarter lb. copper foil.
One lb. dry granular calcium chloride.
Half lb. copper oxide, granulated (pure).
One lb. borax (crystalline).
One oz. turmeric.
Four lbs. sand.
One lb. plaster of Paris, } for making air-tight joints.
Quarter lb. water glass, }
A supply of methylated spirit and paraffin or benzene (to be obtained locally).

N.B.—*All materials should be kept in carefully labelled bottles.*

LIST OF APPARATUS ADDITIONAL TO SETS D, E, AND F REQUIRED FOR THE SECOND YEAR'S COURSE IN A LABORATORY NOT PROVIDED WITH TH APPARATUS FOR FIRST YEAR'S COURSE.

G.

(Apparatus required for each pair of Students.)

One retort stand (height two feet), with two rings and clamp.
Two beakers, 3 inches high, } medium form.
Two ,, $4\frac{1}{2}$ inches high, }
Two iron tripods.

Two wire gauzes, 5 inches square.
Two sand baths.
Two Bunsens (No. 2 size) and rubber tubing.
One 8 oz. flask, with 2 hole rubber stopper.
One 12 oz. flask, with 2 hole rubber stopper.
One 12 oz. flask, with round bottom.
One earthenware or thick glass pneumatic trough.
One 50 cc. burette and stand.
One 25 cc. pipette.
One triangular file.
One rat tail file.
One Mohr's pinchcock, 2¼ inches.
One Centigrade thermometer.

H.

(Apparatus required for each four Students.)

One balance 250 grammes sensitive to 2 mgms. with full load.
One glass case for same.
One box wts. 100—·001 grm. (superior).
One earthenware or stout glass pneumatic trough, 10 inches by 4 inches.
One bell-jar and stopper, 9 inches by 4 inches, with one-hole rubber stopper to fit.
One Liebig's condenser, 12 inches.

J.

(Apparatus and materials required for general use.)

Two litre flasks.
Two half litre flasks.
One 250 cc. flask.
One 100 cc. flask.
One each pipettes (1, 5, 10, 20, 50, 100 cc.).
One pipette rack or stand.
Five 500 cc. graduated cylinders.
Five 250 cc. graduated cylinders.
One 100 cc. graduated cylinder.
Three sets cork borers (1-8), } best quality.
One set cork borers (1-10), }
Ten yards rubber tubing, ¼-inch.
*One Fletcher burner and tubing.
Six dozen assorted wood corks.
Two dozen assorted rubber corks.
One reel copper wire.
One lb. copper wire, various sizes.
One pair wire-cutting pliers.
One lb. paraffin wax.
Quarter lb. solid litmus.
Half W.Q. methylated spirit.
One pint ether.
One pint benzene.
One pint paraffin.
Four lbs. sand.
Four lbs. nitre.

* See note, page 82.

Note.—In schools not supplied with coal gas, the items marked with an asterisk are unnecessary; to replace them the following are suggested :—

Sets A and G.—Two spirit lamps, 4 oz.

Sets B and H.—One R. Lang's improved 3-flame spirit lamp.

Set E (additional).—One paraffin or benzene blow-lamp, upright form. One pair salamander crucible jackets, with fire-clay triangle to fit.

Sets C and J.—One Swedish lamp (paraffin)—diameter of grid, 6½ inches. Two German Petroleum boiling stoves—2-inch wick, single burner.

(3.)—PHYSICS.

GENERAL REMARKS.

The courses in Physics are designed not only to extend the pupil's range of knowledge of facts and principles, but also to provide him by means of exact measurement, with opportunities for examining more closely many phenomena with which his previous work has given him only an acquaintance.

In the preliminary course the instruction has been carried out in the laboratory with just such explanation as was necessary to an intelligent understanding of what was being done. Gradually, however, as the work becomes more advanced in character, the teacher will, while retaining laboratory instruction as the essential element, find it necessary to make use of the text-book and the lecture-room.

This should be cautiously done at first. There are two dangers to be guarded against. The pupils may be presented with new ideas at so rapid a rate that assimilation becomes impossible. On the other hand, they may come to regard the exercises as useless repetitions of what has already been done most satisfactorily by eminent investigators. To avoid this latter danger, the teacher should aim at bringing his class to a new exercise in the same mood and with the same intellectual interest as those in which the problem was approached by the first investigators.

Arrangement of Syllabus.

In drawing up syallabuses for such courses, the following considerations have to be kept in view by the teacher: (1) the capacity for assimilation of ideas to be expected from an average pupil at each stage of his progress; (2) the number of hours per session available for the subject; (3) expense and laboratory space required render practically impossible the duplication of any but the smallest items of the apparatus used; (4) under the limitations imposed by the foregoing, the course should cover as large a range of ideas as possible.

The ideal method would be to have the pupils working in the laboratory simultaneously at the same exercise, with the lecture-room work supplementing the practical work. Since it is impossible to secure this, the only available way in which a class of pupils can be taught advanced Physics in the physical laboratory is by a process of rotation of exercises.

Some hints, the results of experience, are given underneath, with a view to help the teacher to arrange his laboratory courses. These hints should be regarded as suggestions, and not as instructions.

Suggestions as to Course of Work.

A decision as to what exercises should be performed by the class, and the order in which they should be taken, must be largely the outcome of experience. The exercises need not necessarily be taken in the order given nor worked in the manner suggested; the order actually followed should, however, be, as a rule, from the less to the more difficult, but always with the evident limitation that the same piece of apparatus cannot be used for more than one exercise at a time. Every good teacher will, sooner or later, come to follow the results of his own experience.

Since the work in the lecture-room is free from the material limitations of the laboratory, it is expected to follow *a well-ordered course*. It should have constant reference to the experiments in progress in the laboratory, and ought to follow such a line of discussion as it would have taken if it had been supplementary to a well-arranged practical course, in which each experiment was worked simultaneously by the class, and one experiment followed another in regular succession. The "rotation process" of the laboratory will tend to break the sequence of the theoretical lessons and to make them unsystematic; but will succeed in doing so only when the organization is inefficient.

Laboratory Work.

It will be observed that by following the suggested arrangement of the laboratory course, some of the experiments will be ahead of the lecture-room work, and other experiments will be behind. This is unavoidable, if expensive apparatus is not to be duplicated; but it is not nearly so great a disadvantage for more advanced workers as it would be for beginners. At first the pupils may find the proposed method of working somewhat more difficult than if each experiment were carried out simultaneously by the class. Very soon, however, the pupils will be found to have grasped readily what is to be done, when set before a fresh experiment with but few instructions.

With a class consisting of twenty pupils working in pairs, the ten exercises in operation at any one laboratory lesson would, therefore, as a rule, be all different from one another

At each laboratory lesson a pair of workers would, in rotation, work one exercise, so that, by the end of ten lessons, a new batch of exercises would require to be provided. The teacher should keep a book, in which the names of the pairs of pupils, with the title and date of the experiments performed by each, are duly tabulated, like attendances in a register.

The columns of titles of the exercises carried out at the previous lessons would show at a glance what exercise comes by rotation to be next worked by any particular pair of pupils, and when a new batch of exercises is due.

Such a register would also enable the careful teacher to reduce to a vanishing quantity delays in a laboratory lesson caused by apparatus not being in working order, since he can tell some weeks beforehand when a particular instrument will be required for use.

For each exercise there should be prepared by the teacher a short paper of instructions, accompanied as a rule, in magnetic or electric work, by a diagram, and giving also a copy of the form in which the observations are to be tabulated by the pupil in his laboratory book. At the end of the lesson this paper should be returned to the teacher for use at the next lesson.

The date, the title of the experiment, and the form for tabulating results should all be entered in his book by the pupil before he begins an experiment. All entries should be in ink, each observation being entered immediately it is made.

The "curving" of the results should be carried out wherever possible.

Since every experiment is designed to discover *something*, the pupil should be taught to write down distinctly in words at the end of the record of his results, what is the conclusion to which those results point. If he cannot tell, it will be the teacher's business, by judicious questioning, to lead him to that conclusion.

For the sake of reference, it will be found a great convenience to number the pages of the laboratory book, and to reserve the first two pages for indexing the title and page of each exercise entered in the book.

When the teacher comes to revise some of the laboratory work, it is expected that he will not content himself with a mere repetition of the exercises already worked through, but will maintain the interest and value of the exercises by varying, when possible, the "unknown" to be obtained from the measurements.

THIRD YEAR SYLLABUS.

SUBJECT:—HEAT, LIGHT, AND SOUND.

HEAT.

Brief recapitulation of previous work in Heat.

Thermometry.

Test the fixed points of thermometers, making correction for barometric pressure.

Determine the boiling points of liquids, noting barometric height.

Observe variation of boiling point with strength of a saline solution.

Expansion.

Measure coefficient of linear expansion of solids.

Make a weight thermometer, fill with glycerine, and determine coefficient of apparent expansion of the liquid.

Find coefficient of cubical expansion of glass by means of a weight thermometer containing mercury.

Find the percentage change of volume of ice and of paraffin wax on melting.

Determine coefficient of expansion of air.

Verify Boyle's law for gases for pressures above and below that of the atmosphere.

Vapour Pressure.

Find the vapour pressure of such a liquid as water for temperatures (*a*) below 100° C., (*b*) above 100° C.

Determine the relative humidity of the air by means of a hygrometer.

Calorimetry.

Specific heat of substances by the method of mixtures.
Latent heat of fusion of ice.
Latent heat of vaporisation of water, and of alcohol.
Joule's experiments and the mechanical equivalent of heat.

Radiation.

Comparison of emission of radiant heat from surfaces at the same temperature.

Observations on the transparency of different thickness of such a substance as glass, for heat from a bright and a dark source.

LIGHT.

Principles and methods of photometry.

Reflexion: images formed by plane mirror; parallel and inclined plane mirrors; concave spherical mirrors and the images formed by them.

Refraction: index of refraction; total internal reflection, refraction by prism; convex and concave lenses and images formed by them. Principle of telescope and microscope should be illustrated by skeleton models showing construction.

Dispersion: composite character of white light; general theory of the spectroscope.

Practical Work in Light.

Find the candle power of a flame.

With plane mirror prove relation between angle of incidence and angle of reflexion; find relative positions of object and image. Observe images formed by two parallel plane mirrors; also when the mirrors are inclined to one another.

From positions of object and image, find radius of curvature of concave and convex mirrors.

Measure index of refraction for glass (1) by deviation of rays; (2) by measuring the real and the apparent thickness of the glass. Draw caustic of refraction; observe total internal reflection.

Measure approximate deviation produced by prism with various angles of incidence.

With convex and concave lenses find how sizes of object and image are related to their distances.

Find focal length of convex and concave lenses by (1) a distant source of light; (2) by use of plain mirror; (3) near source of light.

Observe through a prism the appearance of (1) a white strip laid on a dark background; (2) a dark strip laid on a white background.

Measure with spectrometer the angle of prism, and the index of refraction for, say, sodium light.

With spectrometer observe the solar spectrum, and note the readings of the positions of the most prominent dark lines. Compare with the positions of the bright lines shown by the vapours of various metals.

SOUND.

The exercises in Sound which the class can work in the Physical Laboratory are limited in their character by the serious difficulty that each pair of pupils would, as a rule, require a room for themselves. Such exercises as are possible in a practical course for a class would therefore need to be largely supplemented with demonstrations by the teacher assisted by the pupils wherever possible.

In a well-arranged series of demonstrations the ideas to be conveyed will unfold themselves in an orderly manner, each observation or measurement leading on to the next, and the class ought to be able to draw most of the deductions from the observed facts.

It is suggested that the teacher should demonstrate the leading facts about sound somewhat in the manner indicated below.

Propagation of Sound illustrated.

1. A row of balls, similar in elastic properties to ivory; show effect of a collision by one, two, or three balls, on the others of the row.

2. Prove that a ball, like those just used, changes shape by a blow, by dropping it from a small height, and then from a greater, on to a stone slab where there is a patch of red paint thinned down with oil. Observe the sizes of the red marks on the ball.

3. Hang vertically from the ceiling a long spiral, about 3 cms. diameter, made of thin brass wire (about No. 22). Pull down the lower end and suddenly let go. The resulting impulse (a condensation) is easily followed by the eye as it travels along the spiral. Notice the difference in the nature of the reflected disturbance according as the reflexion takes place at the upper (fixed) end, or at the lower (free) end. How many times does the disturbance pass along the length of the spiral before it reappears as a condensation at the lower end?

In some such ways, the teacher can lead his class to the understanding of how sound is propagated by means of the elasticity of the medium; what is meant by a wave of sound, and by the length of the wave. By sending a small condensation or rarefaction along the spiral spring, and again a comparatively large condensation or rarefaction, the teacher can bring his class to see clearly that the length of such waves, and the extent of the motion of the individual particles are completely independent of each other.

4. Set the spiral spring vibrating as above, count the number of complete vibrations performed by the lower end, and also measure the length of the spring. The class should be easily able to calculate the speed with which an impulse passes along the spiral. The important point thus brought out can be enforced by varied numerical examples to be worked by the class.

5. A long cylindrical jar of air is suddenly struck at the mouth by the hand. The general nature of the resulting motion of the air in the jar ought to be now easy for the class to describe. How many cms. long is the wave?

6. Show that if a tuning fork is sounding, the prongs are in motion; for example, by making them touch the surface of water; or by touching a suspended pith ball: it can be shown that as the sound dies away, the motion of the prongs of the fork is getting smaller.

Resonance and Velocity of Sound.

7. A small A. fork, and a 5 oz. bottle with a mouth about an inch wide. A piece of glass about an inch-and-a-half long and an inch

wide slid gradually over the mouth of the bottle will serve to tune the air inside, until it resounds most loudly to the vibrating fork. Fix on the glass slip with wax.

8. Send a puff of breath across the opening in the mouth of the bottle: compare the pitch of the resulting note with the pitch of the note of the fork. The same point can be illustrated by taking a common earthenware jug, sending a puff of air across the mouth of it, and then showing that the air in the jug resounds to a note of that pitch sung or spoken by the voice. Many common examples will suggest themselves.

9. The velocity of sound in air can be measured approximately by use of a tuning fork of known frequency, say, 384 vibrations per second, and a glass tube about 60 cms. long and 3 cms. diameter, arranged so as to slide easily into a tall glass jar full of water. If the tube be gradually pulled out of the water, two positions of maximum resonance can be observed. Measure the lengths of the air column in the tube for each position, and find how the lengths are related to each other. A puff of breath sent across the open mouth of the tube in the two positions will show how the pitch of the resulting note is in each case related to the pitch of the fork. Calculate the velocity of sound in air.

10. Repeat the experiment, using carbonic acid gas in place of air in the tube, and this time pushing the tube into the water whilst searching for the positions of maximum resonance. Thus find how the velocity of sound in a gas is related to the density of the gas.

11. The same apparatus as in (9) above may be used for comparing the frequencies of two tuning forks, a large G. and a large C.; if one be of known frequency, the frequency of the other can be found.

12. The application of the principles of resonance to organ pipes should be shown by use of open fine pipes. The effect on the pitch of the note produced by closing the open end wholly, and partially, can be observed. Note the presence of harmonics.

Interference and Beats.

13. Use a bottle tuned to an A. fork as in (7) above, and twirl the vibrating fork slowly close to the opening in the mouth of the bottle.

14. Take two such bottles, each tuned to the A. fork. Set one bottle upright and the other horizontally, with the mouths of the bottles nearly touching. Bring down the vibrating fork horizontally so that the space between the prongs is opposite the opening in the upright bottle. Try also the effect when the opening in one of the bottles is covered with a slip of cardboard.

15. Intermittent interference, or beats, can be exhibited by two forks, for instance, one having a prong loaded with a small piece of wax. The use of beats in finding the difference of frequencies of two sounds, and also in the adjustment of two notes to unison should be pointed out. The relation between beats and record of notes, should be illustrated.

APPARATUS FOR DEMONSTRATIONS IN SOUND.*

Row of balls carried by threads on frame, or fitting in a groove on a board.

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* It is not considered necessary to give a list of apparatus for the other subjects.

Spiral 3 cms. in diameter, of thin brass wire (about No. 22) to be suspended by a hook from the ceiling above lecture table, and to be sufficiently long to come within about 12 inches of the top of table.

Tuning forks: two small of A.; one of C.; one of G.; one large of C. mounted on resonating box; one large standard G. fork, mounted on resonating box of frequency 384, which is stamped on box.

One 'cello bow.

Monochord.

20 feet of steel pianoforte wire, No. 22; same, No. 24; same of brass wire, No. 22.

Two flue wooden organ pipes; one 21 inches long, the other $10\frac{1}{2}$ inches. These should approximately sound C. in octaves.

Long flexible rope or thick cord.

Rod of mahogany about half-inch diameter and 6 feet long.

Clamp for the above, formed of two wooden blocks which can be brought towards one another by two screws.

Apparatus for use in Laboratory.

2 steel spiral springs, about 9 inches long, such as used for door-bell pull.

2 wooden laths accurately planed, 30 inches, by 1 inch, by $\frac{3}{16}$-inch.

2 iron clamps for the same.

2 small camel hair brushes with which to obtain traces from the laths.

FOURTH YEAR SYLLABUS.

Subject:—MAGNETISM AND ELECTRICITY.

Introductory.

At this stage of the pupil's work he will have acquired some considerable skill in experimenting. By reason of his age and the experience he has had in manipulation he will be found capable of understanding and conducting successfully experiments with more elaborate and delicate apparatus than he has hitherto used. He will, indeed, not be satisfied to continue long at work on experiments whose bearings he can see at a glance. This very desirable sign of progress has, accordingly, to be met with a corresponding degree of development in the nature and complexity of the ideas presented to the pupil, both in the laboratory and the lecture room, if his interest in the work is to be sustained.

The suggested syllabus of practical work underneath is proposed as a result of experience of what pupils at this stage can successfully undertake. To the teacher of experience, again, the syllabus will suggest the corresponding work of the lecture-room.

During the first part of the session, whilst the simultaneous experiments (*a*), (*b*), (*c*) are in progress, there will be practically no distinction between laboratory and lecture-room work, for each experiment, usually short, will be followed immediately by a statement in the pupil's own words of the conclusion to be drawn from it.

Fundamental Laws and Experiments.

(*a*) Electrostatics: fundamental phenomena.
Electrification by friction and by conduction; + and — electrification; conductors and insulators; electrostatic induction.

(*b*) Magnetism: fundamental phenomena.
Attraction of iron by a magnet: action of magnetic poles on each other; directive property of a magnet; magnetic induction; lines of magnetic force, as shown by a short compass needle, and by iron filings.

(*c*) Voltaic electricity: fundamental experiments.

(The experiments (*a*), (*b*), (*c*) above can be carried out simultaneously by the class.)

Find the form of the lines of electrostatic force for various simple cases.

As an example, set up two tin cans on insulating stands, about 50 cms. apart, and so that their bottoms are about 15 cms. above the table. Connect each to one terminal of a Wimshurst machine. An exploring "needle" can be made with 5 cms. of stiff fine wire, a small pith ball being stuck on each end. This needle is suspended so as to hang, for instance, about the height of the middle of the cans. A suitable pointer, to move close to the large sheet of paper lying on the table underneath, can be formed from a very thin slip of ebonite, about the same length as the needle. This pointer can be made to follow the needle in its motions by attaching it to the latter by two equal and parallel lengths of cocoon fibre. Thus the lines of force are easily drawn on the sheet of paper. The needle is itself carried by cocoon silk fibre, fastened at the upper end to a long ebonite strip. If this strip be clipped between the jaws of a "universal stand," the necessary adjustments are easily made.

Properties of Magnets examined quantitatively.

Distribution of the force on a bar magnet by weighing the attraction of a small iron sphere.

Comparison of the force exerted by a short bar magnet in the A and B Gauss positions.

Prove that for one pole of a long steel strip, force × $(\text{distance})^2$ is constant.

Prove that for a point in the A or B Gauss position with respect to a short bar magnet, force × $(\text{distance})^3$ is constant.

Comparison of the magnetic moments of short bar magnets by the method of inverse cube of the distances.

Prove that when a fine cord carrying a load W is displaced from the vertical through an angle θ, by a horizontal pull U, then $U = W \times \tan\theta$.

Comparison of the magnetic moments of short bar magnets by the method of tangents of deflexion.

Determine approximately the angle of dip by induction in soft iron (strip of tin plate).

Comparison of Electromotive Forces.

Find the E.M.F. of different voltaic combinations by help of quadrant electrometer and Clark cell.

Action of Galvanometer and of Electromagnet.

Compare the force exerted by a current in a coil without, and with, an iron core.

Action of Galvanometer examined quantitatively.

Determine how the force exerted by a current in a coil depends on (1) the number of turns of wire, (2) the mean radius of the coil.

Ohm's Law.

Verify Ohm's law by use of resistance box and mirror galvanometer.

Verify Ohm's law by use of quadrant electrometer and resistance box.

Compare the E.M.F. of cells, and combinations of cells, by use of resistance box and mirror galvanometer.

Find the calibration curve for low resistance galvanoscope by help of resistance box and steady cell.

Find the resistance of coils of wire by method of substitution.

Determine the resistance of steady cell by help of resistance box and tangent galvanometer.

Compare the E.M.F. of cells by use of resistance box and tangent galvanometer.

Wheatstone Bridge for comparison of resistances.

Find resistance of coils of wire by P.O. form of Wheatstone bridge.

Make approximate one ohm coil, and measure its resistance.

Find the specific resistance of the materials of wires by metre bridge.

Electrolysis.

Find the constant for tangent galvanometer by electrolysis of copper sulphate.

Thermo-electricity.

Thermo-electric currents: connection of galvanometer deflexion and temperature—difference of junctions for various couples.

Observe the existence of a neutral point, and inversion of current, by continuous raising of the temperature of a copper-iron thermocouple.

Electro-magnetic Induction.

Experiments on electro-magnetic induction with two coils; test effects of (1) magnitude; (2) direction of primary current; (3) relative position of coils; (4) iron cores of various diameters.

Distribution of magnetic force on a bar magnet by sliding a small coil step by step along the bar.

Determine the angle of dip by use of a coil of wire and mirror galvanometer.

Heating effect of Currents.

Determine the mechanical equivalent of heat by an electrical method.

(4.)—CHEMISTRY.

THIRD YEAR SYLLABUS.

Introductory. At the conclusion of the Second Year of the Preliminary Course, a student, from his own experiments, should be convinced of the truth of the *Law of Definite proportions*, and should fully realise the unvarying composition of a pure compound. He should understand what is meant by the term *Equivalent*, and should have appreciated the reciprocal nature of Equivalents (*e.g.*, that 12 gms. of magnesium, and 8 gms. of oxygen, are equivalent to 1 gm. of hydrogen; and also that 12 gms. of magesium are equivalent to 8 gms. of oxygen).

He should have a clear idea of the composition of air, water, and chalk, and should have arrived at a full general understanding of the nature of combustion.

Common Salt.—This substance has been already examined, and it has been found that by the action of sulphuric acid a gas is evolved, the solution of which in water is an acid, from which metals displace hydrogen. The gas may be further studied, as well as the acid solution.

Hydrochloric Acid Gas.—Action of gas on heated zinc and heated copper oxide; presence of hydrogen in the gas; examination of other products. Action of hydrochloric acid on *oxide of copper* (and other oxides), *litharge*,* and *red lead*. (The products should in each case be examined, and the general nature of the action of an acid on a base further illustrated.) Comparison of the actions in cases of litharge and red lead; the *greenish-yellow gas* due to the *extra* oxygen of the red lead. Action of other *peroxides*, especially manganese peroxide.

Chlorine.—Its preparation and properties. Hydrochloric acid gas being hence recognised as hydrogen chloride, its quantitative examination should be commenced.

Quantitative Study of Hydrogen Chloride.—Action of sodium on the gas over mercury. Gas contains one-half its volume of hydrogen. (It is important to emphasize that this gives *no evidence* regarding volume of chlorine.)

Determination of the weight of a litre of hydrogen chloride, and of chlorine, and observation that the weight of 2 litres of hydrogen chloride, minus the weight of the contained litre of hydrogen, equals the weight of one litre of chlorine, as already determined. (The weight of a litre of hydrogen may be assumed.)

Comparison of densities of chlorine and hydrogen. Equivalent of chlorine.

[These experiments serve as a convenient introduction to the molecular conceptions of modern Chemistry. Reference having been previously made to the "*atoms*" of Dalton and the "*molecules intégrantes*" of Ampère in connection with the facts of chemical combination in definite and simple proportions, both by weight and by volume, and the uniformity in the physical behaviour of gases, the conclusions arrived at by Avogadro and Cannizzarro with respect to the complexity of these "atomic" individuals, should now be introduced and the conception of molecules fully explained. Symbols and very simple equations may be slowly introduced, but only in cases of well-studied changes.]

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* Use pure massicot.

Water.—Study of the behaviour of sodium towards water and the action of dry caustic soda on zinc would lead to the recognition of two separately replaceable quantities of hydrogen in water. Determination of the composition of water by weight and by volume (analytically and synthetically—hence formula (assuming density of water vapour). Difference between combining power of atoms of oxygen and chlorine.

Equivalent weights of metals which combine easily with chorine or with oxygen :—

Sodium.—By weighing sodium in small test-tube, and adding it in small pieces to dilute hydrochloric acid in a weighed basin.

Silver.—By reduction of silver chloride by hydrogen, or by converting silver into silver chloride.

The equivalents of zinc and magnesium previously found by replacing hydrogen in hydrochloric acid may be again recalled. (Students should appreciate that these equivalent weights stand on a direct experimental basis, and involve no atomic hypothesis or conception.)

Examination of Chlorides.—A number of Chlorides have been prepared during this work, and it is advisable to occasionally collect and correlate notes on these.

Nitric Acid.—Preparation has been already studied. It may be again examined, as well as the product left in the retort.

Action of Nitric Acid on metals—e.g., zinc, tin, iron, copper, magnesium. Oxidising action of nitric acid. Gases evolved should be studied. *Copper and nitric acid.* Gas collected over water; evidence of two gases: red, soluble; colourless, insoluble. Study of latter; combustion in this gas—effect of air or oxygen—quantitative action of oxygen. By study of products of combustion, presence of oxygen in the gas deduced. Heating of potassium or iron in the gas, and deduction that gas contains one-half volume of nitrogen. Density of gas, and establishment of formula.

Properties of the red gas. Composition deduced from previous work (*i.e.*, formula of nitric oxide and reaction with oxygen). *Zinc and nitric acid.* Production of gas which does not yield red fumes with air. (Use 15 per cent. solution of nitric acid.) Collection over water (slight solubility should be observed). Properties of gas, and difficulty of obtaining in state of purity by this method.

Evaporation of product formed by action of zinc and nitric acid, and heating with lime—smell of ammonia—hence a reduction product of nitric acid.

Examination of ammonia—solubility—combustion in oxygen —composition from decomposition by chlorine, and density.

Formation of salts of ammonia—ammonium chloride—sulphate—nitrate. Heating of ammonium nitrate—formation of gas, obtained previously by action of zinc and nitric acid. Properties of this gas—density—and composition from decomposition by potassium or sodium.

Heating of metallic nitrates, as copper nitrate, lead nitrate, &c., and study of changes.

Composition of the three oxides, N_2O, NO, and NO_2, being known, the *Law of Multiple Proportions* may be illustrated.

Sulphuric Acid.—The action of the dilute acids on metals has been already investigated. The action of the concentrated acid, cold and hot, should be studied.

Action of concentrated Acid on Copper.—Recognition of gas evolved as that produced by combustion of sulphur, *i.e.*, oxide of sulphur. (Sulphuric acid therefore contains sulphur and oxygen: hydrogen has already been shown to be present.)

Properties of gas—acid solution—formation of salts—sulphites—properties of sulphites.

Examination of substances left in flask—*copper sulphide*—*copper sulphate*, &c.

Quantitative study of Sulphur Oxide, Sulphur burning in air or oxygen produces no change in volume—density of gas—these suffice to establish formula (with $S=32$). Preparation and examination of octahedral, prismatic and plastic sulphur. Density of each. Observation of time changes. Examination of the gas produced by burning each variety in air or oxygen. Determine whether equal amounts of the same gas are produced by burning equal weights of each variety in a closed volume of oxygen and opening under water.—Preparation of *sulphur trioxide*—the solution of this is *sulphuric acid*—formula of sulphuric acid. This may be verified (or at least supported) by determination of weight of sulphate produced from a known weight of an oxide.

Illustration of manufacture of sulphuric acid—action of the oxides of nitrogen.

Sulphides.—Heating of copper (powder or filings) with sulphur until constant weight is obtained. Similar experiment with *very fine* iron filings—examination of products—action of acid—examination of gas evolved. (Combustion of gas suggests sulphur and hydrogen).

Production of *Sulphides*. Use of gas in detection and separation of salts. Quantitative examination. Decomposition by heated tin (most easily effected in tube drawn out at both ends containing tinfoil, and afterwards opened under water), and density.

Action of acids on sulphides compared with action on oxides, and equations used.

Study of the Metals.

Results obtained in the previous work should be collected under each metal, and only the gaps should now be filled in. Students should be familiar with the formation of insoluble salts by precipitation, and should be able to recognise any of the metallic and acid radicles included in the following list. Mixtures will not be given for analysis.

Sodium.—Hydroxide, carbonate, chloride, nitrate, sulphate. Recognition by flame test.

Potassium.—Hydroxide, carbonate, chloride, nitrate, sulphate. Flame test.

Ammonium.—Hydroxide, carbonate, chloride, sulphate nitrate. Recognition by volatility and evolution of ammonia.

Calcium.—Oxide, hydroxide, carbonate, chloride, sulphate. Recognition by insoluble carbonate (but soluble sulphide, flame test and slightly soluble sulphate.

Zinc.—Oxide, carbonate, chloride, sulphate, sulphide, nitrate. Detection by behaviour of oxide on heating, and by sulphide.

Iron.—The two sets of salts obtained from iron should be studied. Sulphate and nitrate form examples yielding green and brown hydroxides. The case of conversion from green to brown by atmospheric effect suggests a difference of oxidation—ferrous and ferric hydroxides—ferrous and ferric salts—mode of conversion from one to other by oxidising and reducing agents, *e.g.*, nitric acid and hydrogen (by zinc)—*sulphates, chlorides.* Detection of salts of iron by precipitation of ferric hydroxide.

Copper.—Oxide, sulphate, chloride, nitrate carbonate, sulphide. Precipitation of hydroxide and conversion to oxide—effect of heat on chloride—*cuprous chloride*—formation also from copper and cupric chloride. Cupric and cuprous salts—reduction of copper oxide.

Detection of copper by colour of solution; deposition of metal; dry test, and insoluble sulphide.

Lead.—Oxides, litharge, red lead—chloride—sulphate—nitrate—carbonate—sulphide. Reduction by charcoal; extraction of lead. Detection by chloride, and by dry test.

FOURTH YEAR SYLLABUS.

Introductory.

The course of work which is outlined in the following syllabus will, it is hoped, form a fitting conclusion to the study of Chemistry in Secondary Schools. The feature of the syllabus is the great stress which is laid on the thorough study of typical substances, processes and changes.

By a thorough investigation of the chemical constitution of some well selected compounds, the student will become acquainted with the most important methods in chemical research, and the necessity for care and skill in manipulation will be clearly impressed upon his mind. The educational value of such work will largely depend on the way the problem is presented to him and every effort should be made by the teacher to use such investigation as a means of training in scientific method rather than as a mere test of manipulative skill. The syllabus provides scope for the skilful and enthusiastic teacher; thus in dealing with tin and aluminium the influence of minute variations in the composition on the properties of alloys forms an exceedingly interesting side issue. In dealing with silver the subject of photography would naturally arise. When the students have from their own experimental work arrived at the formulæ of such substances as carbon dioxide and crystalline copper sulphate, it is hardly necessary for them to investigate the composition of every new substance they may have to deal with, for, having learnt the principles and methods by which the compositions of substances are determined by chemists, they will be able to appreciate the work of others, and to use without further question results accepted by common consent among chemists.

Recapitulation.

At the beginning of the fourth year it would be well to recall the previous work in regard to the densities of elementary and compound gases ($H = 1$ or $O = 16$), the meaning of the terms *atom*, *atomic weight*, *molecule*, *molecular weight*, and the full bearing of *Avogadro's Hypothesis* and *Gay Lussac's Law of Volumes*. The pupils following this course are expected to have a competent knowledge of the matter of the preceding courses.

Diffusion.

Demonstration experiments on the diffusion of gases and statement of *Graham's Law* should at this juncture prove of considerable interest, and should lead to an elementary consideration of the *kinetic theory of gases*.

Atomic weight of Metals.

It should be pointed out that although much was learnt about the equivalent weight of metals no determination of their atomic weights was made in the third year course. To bring out the difference in the combining power of atoms of metals, careful experimental study of the replacement of hydrogen in sulphuric and hydrochloric or nitric acids should be undertaken with potassium and zinc or magnesium. The equivalent weights being previously known and an indication of the valency being thus arrived at, the atomic weights of the metals should be calculated. Reference should then be made to the cases of silver, aluminium, lead, &c. During this work the basicity of acids should receive consideration. Determination of the specific heat of metals of known atomic weight (zinc, lead, silver and aluminium). *Dulong and Petit's Law*. Application of this law to the determination of the atomic weight of metals (using nickle or antimony).

Determination of empirical formulæ gravimetrically.

Determination of the percentage composition by weight, and hence empirical formulæ, of carbon dioxide, sodium chloride, crystalline copper sulphate. This will involve the preparation of pure substances and the accurate determination of carbon as carbon dioxide, of chlorine as silver chloride, of copper as copper oxide, of sulphuric acid as barium sulphate, and of water of crystallisa tion The preparation, properties, and composition of carbon monoxide should receive consideration when dealing with the analysis of carbon dioxide.

Determination of Molecular Weights.

Determination of vapour density and molecular weight of easily vaporised compounds such as water, carbon bisulphide, and chloroform. Summary of the work on the determination of molecular weights and formulæ.

Halogens.

The comparative study of the halogens and their compounds with hydrogen and the metals affords an excellent opportunity for illustrating the existence of families of elements, Another typical family, such as barium, strontium, and calcium, should be considered briefly, and the *periodic system* dealt with in an elementary way.

Silicon

Occurrence in nature—general properties of its important compounds.

Metals.

Minute study of the important metals, silver, tin, and aluminium, in so far as they have not been already considered. Occurrence of metals in nature and the principal methods for obtaining them from their ores, namely, (*a*) Reduction with carbon, (*b*) electrolysis, (*c*) substitution of one metal for another, (*d*) partial oxidation of sulphide and mutual reduction. Illustration of those processes by reference to the more common metals—details of manufacture not required.

Analysis.

Qualitative.—Pupils should be able to recognise any ot the metallic and acid radicles studied in the course.

Quantitative.—(1.) *Gravimetric.*—Five typical gravimetric determinations included above.

(2.) *Volumetric.*—Preparation of Standard solutions of sodium carbonate and sulphuric acid—use of indicators—determination of acids and alkalies—use of permanganate of potash—standardisation by ferrous sulphate and measurement of ferrous and ferric iron: Volumetric estimation of chlorides by silver nitrate.

Organic Chemistry.

Distillation of sawdust.—Separation and identification of acetic acid and methyl alcohol in distillate.

Acetic acid.—Study as a type of fatty acids; basicity; preparation of sodium acetate leading to preparation of methane (type of paraffin series); statement of constitutional formula for acetic acid

Methyl alcohol.—Study as a type of primary alcohols; analogy to water shown by action of sodium; action of phosphorus and iodine—preparation of methyl iodide (type of alkyl halogen compound); action of sulphuric acid and oxidising agents on methyl or ethyl alcohol.

Paraffins.—Production of methane (i.) as above, (ii.) by reduction of methyl iodide by zinc-copper couple. Synthesis of ethane by action of sodium on methyl iodide.

Historical Chemistry.

During the whole course endeavour should be made to interest the pupils in the work of the great chemists. Thus during the elementary course the work of Priestly, Lavoisier, Black, and Cavendish, may be referred to. In the third and fourth year courses many opportunities occur for further references to these chemists, and for adding some account of the work of Davy, Dumas, Dalton, and Graham. At the end of the fourth year, a student should have an idea of the general history of chemistry during the eighteenth and nineteenth centuries, and should be familiar with the chief work of the chemists mentioned above.

APPARATUS REQUIRED FOR THE THIRD YEAR COURSE IN CHEMISTRY.

These lists will serve as guides only; the exact requirements will depend on the present laboratory equipment of apparatus and stock of materials in each school.

(a.)—For every two students.

Basins, evaporating, 2½ inches, 3½ inches.
Beakers, 3 inches, 4 inches—2 each.
Blow-pipe.
Bottles, supply of N.M. for ordinary bench reagents.
Bottle, W.M. 8 oz., with thistle funnel and delivery tube.
Charcoal, hard—one piece.
Crucibles and lids, No. 0 and 2.
Crucible tongs.
Deflagrating spoon.
Desiccator.
Earthenware trough.
Files, triangular and rat-tail.
Fireclay triangles—2.
Flask, 8 oz., with 2-hole rubber stopper.
Flask, 12 oz., " " " round bottom.
Flasks, 8 oz., conical—3.
Funnels—2.
Funnel stand.
Gas jars—3.
Glass tube, hard, ⅛-inch bore, 1 foot long—2.
Iron gauze, one piece 5 inches square.

Litmus papers, red and blue—one box of each.
Platinum wire—4 inches.
Porcelain boat.
Retort, 8 oz., with receiver.
Retort stand, with 2 rings and clamp.
Rubber stoppers to fit hard glass tube, one hole—2.
Rubber tubing, ¼-inch—2 feet.
Sand bath.
Test-tube brush.
Test-tube stand.
Thistle funnels—2.
Tripod stand.
U-tube, fitted with 1-hole stoppers.
Wash bottle.
Watch glasses—2.

(b.)—For every four students.

Balance, sensitive to ·2 mg.
Measuring Cylinder, 250 c.c. (in 2 c.c.).
Weights, accurately adjusted—one box.

(c.)—Stock apparatus.

Accumulators—2, or Bunsen cells—4.
Blow-pipe (foot), and bellows.
Boiling-tubes—½ gross.
Crucibles—12 each size.
Drying ovens—2.
Evaporating basins—12 each size.
Eudiometer tube.
Files, triangular—6.
Filter papers, 10 cm.—2,000.
Flasks, 8 oz.—12.
Flasks, round-bottomed—12.
Flasks, 2-litre—2.
Flask, 2½-litre, wide mouth.
Glass rods—2lbs.
Glass tubing, assorted—6 lbs.
Glass tubing, hard—4 lbs.
Graduated cylinders, 500 c.c.—2.
Ignition tubes—60.
India rubber tubing, ¼-inch—6 feet.
India rubber tubing, to fit Bunsens used—6 feet.
Induction coil, small.
Measuring flasks, 1-litre—4.
Mercury trough.
Muffle furnace, with tongs.
Pestles and mortars—4.
Platinum foil, 2½ inches by 1 inch—6 pieces.
Platinum wire—2 feet.
Test tubes, 5 inches by ⅝ inch—2 gross.
Test tubes, 5 inches by ¾ inch—1 gross.

Test tubes, 2 inches by ½ inch—½ gross.
Thermometers, reading to 200° C.—10.
Thistle funnels—6.
Tube for ammonia composition
Voltameter, water.
Woulff's bottles—3.

(*d.*)—*Chemicals.*

Ammonium carbonate—¼ lb.
Ammonium chloride—2 lb.
Ammonium hydrate—one W. quart.
Ammonium nitrate—2 lb.
Ammonium sulphate—¼ lb.
Antimony, powdered, ¼ lb.
Bleaching powder, 1 lb.
Borax—1 lb.
Calcium chloride, granulated—2 lb.
Calcium sulphate—2 lb.
Carbon bisulphide—half W. quart.
Caustic potash—2 lb.
Caustic soda—2 lb.
Common salt—5 lb.
Copper chloride—½ lb.
Copper nitrate—¼ lb.
Copper oxide—1 lb.
Copper sulphate—2 lb.
Copper turnings and foil—2 lb.
Ferric chloride—¼ lb.
Ferrous sulphate—2 lb.
Hydrochloric acid—three W. quarts.
Iron filings—3 lb.
Iron sulphide—2 lb.
Lead carbonate—½ lb.
Lead nitrate—¼ lb.
Lime—2 lb.
Litharge—2 lb.
Magnesium—2 oz.
Manganese dioxide—4 lb.
Mercury—5 lb.
Nitric acid—two W. quarts.
Phosphorus—¼ lb.
Potassium—¼ lb.
Potassium carbonate—¼ lb.
Potassium nitrate—2 lb.
Red lead—3 lb.
Silver nitrate—¼ lb.
Sodium—½ lb.
Sodium carbonate—3 lb.
Sodium sulphate—1 lb.
Sodium sulphite—¼ lb.
Sulphur—5 lb.
Sulphuric acid—four W. quarts.

Tin—1 lb.
Turpentine—½ pint.
Zinc, granulated—1 lb.
Zinc carbonate—¼ lb.
Zinc oxide—¼ lb.
Zinc sulphate—1 lb.

Additional Apparatus required for the Fourth Year Course.

(*e.*)—*For every two students.*

Burette, with stopcock.
Calorimeter.
Condenser.
Condenser-holder.
Distillation flasks, 200 c.c. and 500 c.c.
Platinum foil.
Potash bulbs.
Thermometer, reading to $\frac{1}{5}$° or $\frac{1}{10}$° C.
U-tubes, fitted with 1-hole I.R. stoppers—two.
Weighing bottle.

(*f.*)—*For every four students.*

Dropping funnel.
Separating funnel—small stoppered with long tube.
Vapour density apparatus.

(*g.*)—*Stock apparatus.*

Crucibles, bone ash—10.
Crucible, platinum—one.
Diffusion apparatus.
Filter papers, quantitative, 10 cms.—500.
Glazed paper, black and white—12 sheets.
Lead basins, small for work with H.F.—6.

(*h.*)—*Chemicals.*

Acetic acid—1 lb.
Alcohol, absolute—2 lb.
Alcohol, methylated—one W. quart.
Aluminium chloride—½ lb.
Aluminium sulphate—½ lb.
Antimony, in lumps—2 oz.
Barium carbonate—¼ lb.
Barium chloride—¼ lb.
Baryta—¼ lb.
Bauxite, a specimen.
Bromine—¼ lb.
Benzene—2 lb.
Calcium, a specimen.
Carbon bisulphide, pure—1 lb.

Cassiterite, a specimen.
Chloroform, pure—¼ lb.
Chrome, alum—¼ lb.
Epsom salts—1 lb.
Ether—½ lb.
Ferrous ammonium sulphate, pure—1 lb.
Fluorspar—1 lb.
Iodine—½ lb.
Iron wire, pure—1 reel.
Mercuric chloride—¼ lb.
Methyl alcohol—1 lb.
Methyl iodide—1 oz.
Methyl orange—1 oz.
Microcosmic salt—¼ lb.
Nickel, in lumps—2 oz.
Oxalic acid—1 lb.
Phenol phthalein—1 oz.
Phosphorus, red—¼ lb.
Potash alum—1 lb.
Potassium bichromate—2 lb.
Potassium bromide—2 lb.
Potassium chromate—¼ lb.
Potassium ferricyanide—¼ lb.
Potassium ferrocyanide—¼ lb
Potassium fluoride—¼ lb.
Potassium iodide—1 lb.
Potassium permanganate—2 lb.
Rock crystals.
Silver foil—1 oz.
Silver sulphate—½ oz.
Sodium acetate—½ lb.
Sodium silicate—¼ lb.
Stannic chloride—¼ lb.
Stannous chloride—¼ lb.
Strontium carbonate—½ lb.
Strontium chloride—¼ lb.
Strontium nitrate—½ lb.

(5.)—MECHANICAL SCIENCE.

INTRODUCTION.

General Remarks.

1. In considering the adoption of a syllabus of instruction in Mechanical Science, it is necessary to remember the customary division of Mechanics into the two sections of Dynamics and Statics; and to decide the order in which these shall be taken. The older and perhaps more usual plan is to take Dynamics before Statics; but partly because Statics is distinctly easier than Dynamics, and still more because it is more readily treated experimentally, it is now a common practice to take Statics before Dynamics, or, what is better still, to take them together. It is, for example,

quite easy to arrange a large number of simple and very instructive Statical experiments in the Resolution and Equilibrium of Forces, and in Machines; but it is by no means possible to do so in such sections of Dynamics as Velocity, Acceleration, Momentum and Energy. If then, the theoretical and practical lessons are arranged in the usual way, it will be found quite possible to give all the theoretical instruction in Resolution and Composition of Forces in a few class meetings, and to provide enough experiments to last the class for a much longer time; so that they may continue this subject in the laboratory while the teacher deals with such Dynamical subjects as Velocity and Acceleration in the theoretical class. Every good teacher will see how individual experiments by pupils in connection with the Parallelogram of Forces will help them to understand the Parallelogram of Velocities.

2. Similarly, with the Statical subject of Machines: sufficient theoretical instruction can be given in a few class meetings; and the experiments may be continued afterwards, during which time the teacher can deal with Momentum and Energy, and find more than one useful illustration in the working of such a machine as a pulley block. Generally speaking, Dynamics requires far more class teaching than Statics, while, as already stated, Statics can be very largely taught by individual experimental work in the laboratory. A satisfactory course in Mechanical Science will include both sections; but exactly how they shall be taken is a matter which every good teacher will desire to find out and settle for himself, and on which hard and fast regulations should be avoided.

3. The essential feature of this syllabus is that the subject is to be treated experimentally; and that the experiments are to be performed by the pupils themselves, wherever possible. Further, the method of "discovery" is to be preferred to that of "verification," so that, although the pupil may be told what is meant by the mechanical efficiency of a machine, he should discover for himself how it varies with the load; and although he may be told what is meant by the coefficient of friction, he should be left to find out by experiment the conditions under which it is a constant.

4. The syllabus is also arranged on the understanding that as a rule the whole class will do the same kind of experiment at the same time. There are, however, many parts of Mechanical Science which cannot be so treated since they do not readily lend themselves to satisfying the conditions named: in such cases it is assumed that the teacher will perform the experiments before the class as demonstrations, allowing individual pupils to assist, wherever practicable.

Apparatus.

Atwood's machine, Hicks' ballistic balance, balls rolling down inclined planes, apparatus for measuring centrifugal force, and fly wheels, are necessary parts in the equipment of a Mechanical Laboratory; and are practically the only means of doing experimental work in such fundamental parts of Mechanics as the relations between force, mass and acceleration; in momentum and energy. But school laboratories can scarcely be expected to contain more than one example of each of such expensive pieces of apparatus; if, indeed, they can secure that: and it is, therefore, necessary to restrict the use of apparatus of that character to demonstrations by the teacher, and to individual work by advanced pupils. The difficulty of giving beginners any concrete notion of such parts of Dynamics as acceleration, momentum and energy will be appreciated by all teachers; and any means which can assist in doing so should always be adopted, especially as they are of such vital importance.

5. For reasons already stated, the details in the syllabus given later are restricted to such work as can be undertaken in a school laboratory, with fairly simple and sufficient apparatus, so that the whole class may work at the same kind of experiment concurrently. The syllabus is intended to provide for two years' school work, and to be suggestive rather than definite, in order that teachers may be free to work out their own ideas, and to adapt the course to the special conditions of their own school. For this reason, no attempt is made in the syllabus to distinguish between subjects to be taught theoretically or practically: it is assumed that the theoretical lesson will be regarded as supplementing the practical work rather than as antecedent to it. Sufficient has already been said to show that this will not always be possible.

Certain sections of Mechanics, such as projectiles, impact, &c., are omitted as being outside an elementary course; and for the same reason the more advanced treatment of subjects included in the course will not be expected.

Accuracy.

6. A word or two is desirable as to the degree of accuracy to be expected in the experiments. Very much of the work is in a sense qualitative rather than quantitative, as for example, the relation o the effort to the load in a machine, and its friction and efficiency; again, the value of the coefficient of friction between two plan surfaces will be found to vary considerably with the same piece of apparatus, according to atmospheric and other changeable conditions. On the other hand, the value of many of the experiments lies in accurately recording and measuring the observations and results, and the degree of accuracy, especially when verifying laws, is all-important. As a rule, a high degree of accuracy is only obtainable from carefully constructed and expensive machines; and as an essential feature of the course suggested is that the apparatus should be simple and inexpensive, the problem for the teacher is how to combine these qualities with sufficient accuracy.

With most of the apparatus, the chief difficulty will be found in eliminating friction, and in obtaining spring balances reading to sufficiently small units. Apart from these, it will be found that inaccuracies are more often due to careless observation and measurement or drawing on the part of the student, than to faults in the apparatus. Generally, there is no reason why the same degree of accuracy should not be obtained as in similar work in Physics.

7. With reference to the time to be given to the work of the course, three hours weekly is the minimum time, of which it is desirable that two hours should be given to laboratory work. If an additional half-hour or hour can be given to the working of examples, it will be found of considerable service.

Laboratory Work.

8. The syllabus assumes that in the laboratory lessons the pupils will work in pairs, and that the observations made will be entered neatly in the laboratory note book in ink at the time of working the experiment. In all cases it is desirable to make an outline sketch of the machine or apparatus used, and wherever possible, to plot the results on squared paper, and to draw the "curves." A

useful laboratory book is one having the ordinary line ruling on one side of the page, and one-tenth of an inch squares on the other. Measurements should be made in both metric and British units. While requiring neatness and accuracy in the work done and in the note book record, it is not desirable to give too definite instructions to pupils before beginning an experiment, or to insist too rigidly upon hard and fast methods of entering the results in the note books. It is hoped that teachers will endeavour to give to their classes the same scope for originality and individuality in their work as they will themselves exercise in using this syllabus.

NOTE.—*In revising the syllabuses of this subject, provision has been made for two types of school, which may adopt the subject, viz.*:—(1) *Schools from which Students pass, after leaving the Secondary School, into business, and* (2), *Schools preparing students for a University career. Separate syllabuses are set out for each in the 3rd and 4th year courses, and considerable latitude will be allowed in the application of these syllabuses, but experimental work must form part of all.*

THIRD YEAR SYLLABUS.

Students are expected to have a competent knowledge of the subject matter of the preceding courses, and to secure in this course an acquaintance with the principles of Mechanics by practical work.

GENERAL SYLLABUS.

Measurement of Force.
Resolution and Composition of Forces, including parallel and couples. Levers.
Velocity. Acceleration.
Newton's Laws of Motion.
Mass. Momentum. Impulse.
Work. Energy.
Centre of gravity. Stable, unstable, and neutral equilibrium

ALTERNATIVE SYLLABUS.

[*For Students preparing for the University.*]

Comparison of Forces. Resolution and Composition of Forces.
Moments and Levers.
Velocity and acceleration.
Newton's Laws of Motion.
Mass. Momentum.
Work. Energy.
Centre of gravity. Stable, unstable, and neutral equilibrium.

A more advanced knowledge of the subject-matter of the first year course, with special regard to—

The pressure in a fluid.
The laws of floating bodies.
Specific Gravities.
Gaseous pressure. The barometer.
The pendulum.
Simple hydraulic and pneumatic apparatus.

SUGGESTIONS FOR TEACHING THE THIRD YEAR SYLLABUS.

Measurement of Force.

Preparatory to the use of spring balances and to the measurement of statical forces, an ordinary Salter's spring balance should be tested by hanging on weights, first increasing say from 1 lb. by ½ lb. or 1 lb., and then decreasing. The markings on the balance may be covered by a strip of paper, and the balance re-marked; or, as the extension of an india-rubber rod is sometimes used for the measurement of force, the relation between "tension" and "extension" in such a rod can be found. The rod should be of ⅜-inch or ½-inch diameter, and about 3 feet long, the ends tied in loops, the upper end hanging on a wall hook, with a scale pan on the lower end. A needle pushed through the rubber rod near each end and a metre scale fixed to the wall behind the needlee will enable the extension for the different loads to be read. The results of the experiment with either the spring balance or rubber rod should be plotted on squared paper, and the curves drawn.

It will be useful to let the class determine the effect on the reading of the spring balance by a "suddenly applied load" as compared with one "slowly applied." By slightly lifting the weight on the balance with the hand, and then rapidly withdrawing the hand, the load will be "suddenly applied." If a strip of thin brass be bent round the face of the balance just under the pointer when unloaded, it will be moved down as the spring stretches, and thus enable the maximum reading of the balance caused by the sudden load to be easily recorded.

Resolution of Forces.

Specification and graphical representation of a force. Resultant and components. Parallelogram of forces. Triangle of forces. The best arrangement of apparatus for experiments is a board, about 12 inches by 10 inches, or a cheap half-imperial drawing board, fixed with its plane and long edges vertical, and having a light easy running pulley about 2-inch to 3-inch diameter fixed at each top corner. Three silk cords (about 1/16-inch diameter) have one end of each loosely knotted in a small brass ring, the other ends being free for tying to weights. Two of the cords are placed over the pulleys and the third hangs vertically with a scale pan attached. For the parallelogram of forces, the two given forces are represented by weights tied to the cords which pass over the pulleys, and weights are placed in the scale pan to represent the resultant. A piece of drawing paper having two lines drawn upon it at the given angle of the forces is placed behind the cords, and the weights adjusted until the lines and cords coincide. The paper is then pinned in position, the direction of the resultant marked upon it, and then removed, the parallelogram being completed by drawing. For the triangle of forces, the experiment is very similar. If the experiment is given as finding the conditions of equilibrium of any three forces, then the pulleys may be dispensed with, and small spring balances hung on hooks be used with the two upper cords, the vertical cord having a suitable weight attached. Or the board may be placed upon a table and three spring balances used. In experiments with spring balances, it is best to use larger boards, say of imperial size. Numerous experiments on the triangle of forces can be arranged with such boards and a few spring balances, weights and cord, the following being the most typical:—(*a*) Hanging a weight at one end of a vertical cord, and then pulling the weight to one side until the cord makes a given angle with the vertical, the "pulling" cord being horizontal, and the pull in each cord being found. (*b*) Suspending a weight to some point in a cord, the two ends of which are tied to points in the same horizontal line, the pull in each cord being found. In all experiments of this kind a spring balance is attached to each cord, the pull in which is to be measured.

The experiments should be extended to include the forces in the tie and jib of a simple model crane, the jib of which is attached at its lower end to a compression spring balance; and the tie to a small extension spring balance, a weight representing the load being suspended from the top end. Also a simple triangular roof truss can be made with two stout wood laths, loosely jointed at the apex, the lower ends being held together with a cord and spring balance, which acts as a "tie" and measures the pull when a weight is suspended from the apex. In all experiments of this type, the direction of the cords or members can generally be determined by marking upon a sheet of paper. In working out the results, accurate scale drawings should be made separately of the structure and of the forces, the "structure diagram" and the "force diagram" should be employed.

The step from three to four or more forces, and to the Polygon of Forces is an easy and natural one. The vertical board fitted with a pully at each of the four corners, and having thus five cords, is used to verify the polygon principle; and the model crane having the load cord (which represents the chain) attached to a point in the crane post somewhere between the tie and jib, forms a good experiment with four forces acting at a point.

The triangle of forces board is also used for forces not meeting in a point, by tying the three cords through holes near the edge of an irregular shaped piece of card. For illustrating the "funicular polygon," the larger board should be used with, say, three cords, each having a spring balance to read the pull, weights being tied to each of the two points representing the junction of two cords. The application of the funicular polygon to determining the reactions at the supports of a loaded beam, or the magnitude and position of the resultant of a number of parallel forces, can then be shown, the apparatus for the first experiment consisting of a horizontal wood beam suspended from its ends to spring balances which read the "reactions"; and in the second experiment of a simple lever turning on a fulcrum at its centre, and with weights suspended on each side to represent the parallel forces. The explanation of "couples" should be given in connection with parallel forces.

Centre of Gravity.

Experiments should be performed in balancing rods and circular, triangular and irregular shaped plates of wood or card on the thin edge of a rule or scale. The same plates should be suspended vertically by a cord from three corners or points, the direction of the cord being marked in each case on the plate, and their intersection shown to lie in the "balancing line," and to be the balancing point. Pieces of wood board shaped to triangles and parallelograms, and wood prisms, cones and cylinders should be placed upon a board, and the effect of inclining the board be ascertained. A stop on the board will prevent the solid sliding down, and by covering the board with a sheet of glass, the effect of friction in preventing the tendency of the solid to topple over will be eliminated. In this way, the position of the centre of gravity in the different solids will be found, and the chief properties of the centre of gravity and of stable and unstable equilibrium will be demonstrated.

Moments and Levers.

The meaning of "moment" and the propositions relating to moments can best be illustrated by two simple experiments. In one, a wood lever, divided along one edge into inches and turning about a central fulcrum of cone centres or knife edges, is employed, weights being suspended by strings on each side of the fulcrum. In the other, the polygon of forces board with four pulleys is used with an irregular shaped piece of card having cords from four holes near the edge of the card and passing over the pulleys with different weights tied on. The card is then pierced by a fine bradawl, which, being fixed into the board, forms a point about which the card can turn freely under the action of the pull in the cords. A sheet of paper having been previously pinned on the board, the directions of the cord are marked upon it for any convenient position of equilibrium. The paper is removed, and from each line of direction of a cord a perpendicular is drawn to the turning point. The moment of each weight is thus found, and the sum of the clockwise and anticlockwise moments are compared. A simple bell crank lever can also be made, having a spring balance to read the pull, and a screw for adjustment at the end of the short arm; the long arm being graduated in inches for weights suspended by cords; the lever turning on simple cone centres as a fulcrum. A simple straight lever with an end fulcrum, and with spring balances to represent and measure the upward forces, and weights hung on for downward forces, gives a useful additional experiment as introducing the centre of gravity of the lever.

As the laboratory work already described will occupy many class lessons, the teacher should introduce concurrently those sections of the subject which cannot well be dealt with by individual students. The following sections may be treated in this manner :—

Velocity : parallelogram of velocities : relative velocity.
Acceleration ; falling bodies ; gravity.
Newton's Laws of Motion.
Mass : momentum : impulse.
Work : Energy.

Experiments on these subjects should, where possible, be made by the teacher, with the aid of the pupils if necessary ; and subsequently as occasion offers they may be repeated or extended by students who have completed the earlier parts of the syllabus of practical work.

In this way students are expected to secure acquaintance with Atwood's machine, Hicks' ballistic balance and apparatus for balls rolling down inclined planes, and should be able to express results obtained with facility on squared paper.

FOURTH YEAR SYLLABUS.

General Syllabus.

Elasticity, stress and strain.
Friction.
Work and Energy.

The study of machines.
The Flywheel. Centrifugal force.

As a result of this course, Students should have clear ideas on energy, momentum, and the law of "Conservation of Energy," and should know something of the properties of materials.

ALTERNATIVE SYLLABUS.

[For Students preparing for the University.]

Friction.
Work and Energy: conservation of energy
Machines.
The Pendulum: simple harmonic motion.

SUGGESTIONS FOR TEACHING THE FOURTH YEAR SYLLABUS.

Elasticity, Stress, and Strain.

It is desirable for students of Mechanics to have some notion of elasticity, and of the elastic properties of materials, and as the subject admits of simple and useful experimental work, it is included in this syllabus. The apparatus for the extension of the india-rubber rod already described in connection with the measurement of Force, provides an excellent experiment in elasticity. The extension of the rubber rod with loads increasing up to about 9 lbs. by increments of 1 lb. should be taken, and the readings repeated as the weights are removed pound by pound. Provided the maximum load is well within the elastic limit, the results will be very uniform, and students will readily discover that the strain varies with the stress, and thus be led up to understanding what is meant by a "modulus of elasticity" and its uses. Further experiments can be made with very thin wires of copper, brass, iron, and steel, which can be tested in extension to breaking, the arrangement being similar to that for the india-rubber, except that a more delicate means of measuring the extension is required, which can, however, easily be provided in some simple form of vernier. For the modulus of elasticity of a wire, a long length is required, and this is most conveniently arranged by placing the wire horizontally, one end being fixed to the wall or clamped on table, the other end passing over an easy running wood pulley of about 6-inch diameter, and then vertically downwards to the vernier and scale pan. The length of the wire can be supported on wood pegs.

The elastic laws can also be easily illustrated by loading strips of wood as beams. The beams can rest upon hard wood knife edges screwed to wood blocks abutting from a bench or table, the centre of the beam carrying a light metal stirrup from which the scale pan hangs. The deflection of the beam is measured by a pointer attached to and projecting from the stirrup and moving down against a short length of metre scale. An advantage of these elastic experiments is that they admit of the results being plotted on squared paper and the "curves" drawn, and that for wires they give examples for accurate measurement in the use of micrometer gauges and vernier callipers.

Friction.

Although usually regarded as advanced work, there is no real difficulty in an elementary treatment of friction, and as the apparatus required is quite simple, the subject readily lends itself to experimental work. The friction of simple pulley blocks for a series of loads should be determined; after which, the class should experiment on the friction between a wood slider and a wood board in order to discover that the coefficient is constant with the same two surfaces; that friction is independent of area, and that the tangent of the angle of friction is equal to the coefficient. The friction board may be of pine about 30 inches by 7 inches by 1¼ inches, with one side planed true and smooth, and with a small easy-running pulley at one end. The slider is also of pine about 9 inches by 6 inches by 1½ inches, one face being half cut away so that one area is twice the other. The board is placed horizontally upon a table with the slider at the end farthest from the pulley, a silk cord from the slider passing over the pulley to a scale pan. The slider is loaded with weights, and weights are placed in the scale pan until, when the slider is given a start, it moves along uniformly. The experiment is repeated with seven or nine different loads, and is performed a second time with the slider resting with its half area face on the board. For the angle of friction, the board is inclined by raising one end on weights, and the tangent of the angle of sliding found by measuring the height and base. Pupils should be made familiar with the terms normal pressure, limiting friction, and be given a proof of the fact that the coefficient is equal to the tangent of the angle of friction.

Machines.

The subject of "Work" is most easily dealt with in connection with machines, but there is no real reason why it should not be included at an earlier stage in the syllabus. If much Dynamics has been taken up to this stage, it will have been difficult to avoid some reference to work, although in a somewhat abstract way and without being able to measure it. Machines can be used for illustrations and measurements of work without reference to their properties as machines, and the following experiments may be performed at almost any stage of the syllabus. A load can be placed upon the machine, and weights to represent the "effort" or "force" be placed in a scale pan attached to the driving end of the machine, and so adjusted that, when given a slight start, the effort will overcome the load and raise it uniformly. Knowing the definition of "work," the student measures the distance moved by the "load" and "effort." and thus finds the work done in each case. An equally good experiment is to use an inclined board of wood, with a slider of wood from which a cord passes to a scale pan over a pulley at the top end of the board. The slider with weights upon it represents the "load," and the weights in the scale-pan the "effort" or "force." Then the effort acting through a distance equal to the length of the plane, lifts the load a distance equal to the height of the plane, and the distance being measured, the work in each case is determined. These experiments cannot fail to suggest to students that when work is done, some of it is expended in overcoming resistances such as friction, &c.; and that less work is done by the machine than is given to it.

In connection with their work with machines, students should be familiarised with the meaning and use of the "principle of work," both theoretically and practically; and of such terms as "agent," "power," "horse-power," "energy," "velocity ratio," "mechanical advantage," "mechanical efficiency," and the "friction" of machines. The machines used should include simple cord pulley blocks (one, two, and three sheaves), wheel and axle, Weston's differential chain pulley block, screw jack, and a simple windlass. The pulley blocks need no special arrangements, as weights hung upon the hook of the lower block represent the load, and a scale pan tied to the free end of the cord or hooked in the chain will represent the force or effort. A wheel and axle can be turned from wood and supported by a central iron spindle in blocks of wood to represent bearings which are screwed to ordinary wall brackets. The screw jack requires a wood pulley for the "effort" cord to be fixed to the head of the screw, a stout board on which the load is placed being fixed to the loose cap of the screw above the pulley. A simple windlass will only require to be fixed above the floor on a wooden stand, and to have a wooden pulley fixed to the driving axle for the "effort" cord.

The "velocity ratio" of each machine should be found by measuring the distance moved by the load and the effort or force, and this should be done at least three times; the theoretical velocity ratio being also determined by reasoning. For other experiments, the force or effort required to lift the load uniformly should be determined for seven or ten different and increasing loads, and the mechanical advantage, friction and efficiency should be calculated, the results being plotted upon squared paper in the form of curves.

LABORATORY FOR MECHANICAL SCIENCE.

It is not necessary to set apart a room for use as a Mechanical Laboratory, as nearly all the apparatus can be made movable, so as to be easily fixed on walls, or placed or clamped on tables, or hung on brackets, when required for class work; and at other times stored away in cupboards. Any well lighted room therefore, such as a Physics laboratory, or a Drawing class room, which contains some strong tables and provides plenty of wall space, can be readily utilised. Many pieces of apparatus are best arranged on walls; but if wall space is limited, an excellent substitute can be provided in a vertical framed or boarded wooden stand, firmly fixed to the floor or table top; while a stiff frame of three vertical posts, say of 3 inches by 3 inches and 8 feet high, with horizontal connecting pieces, so that the plan resembles an equilateral triangle, will be found convenient for hanging wires or machines, or for the clamping on of vertical boards. If a room can be set apart as a laboratory, then any oblong shaped room, well lighted and with plenty of wall space and a low ceiling, will meet all requirements. Pulley blocks and similar machines are most conveniently hung from hooks screwed into the ceiling beams, although long-armed wall brackets will serve equally well. Ordinary plain, strong, and movable tables, such as would be used in a Physics laboratory, should be provided, the size being about 8 feet by 4 feet for eight students working in pairs, or 8 feet by 2 feet 3 inches for four students. Fixed benches are not necessary, unless special provision is required for testing beams; and then they are best fixed well away from the wall in order to leave the wall space free. Cupboards or drawers for small apparatus should be provided.

It cannot be too strongly emphasised that objections to undertaking the course on the ground of having no suitable room should not be made, since, with a little ingenuity, and some extra trouble in arranging for and clearing away after each class, almost any class room can be used and useful work done.

SUGGESTED LIST OF APPARATUS REQUIRED FOR THE COURSE OF MECHANICAL SCIENCE.

The following list of apparatus is required for a class of twelve students working in pairs; and provides sufficient for all the students to be working at the same kind of experiment at the same time. The experiment need not be with precisely the same apparatus, as, for example, an experiment in extension may be with a rubber rod, or a spring balance, and in machines with a pulley block or screw jack. Apparatus such as weights, &c., for general use is given separately at the end of the list.

Extension.—6 lengths of ⅜-inch or ½-inch round white rubber rod 3½ feet long; needles about 3 inches long.

Measurement and Resolution of Forces.

Triangle, Parallelogram, and Polygon of Forces.—2 boards, 23 inches by 15½ inches, half-imperial size common drawing boards, each provided with 2 aluminium pulleys 2 inches to 3 inches diameter, with screw cone centres, 4 boards 31 inches by 23 inches Imperial drawing boards), two being provided with 4 pulleys, the other boards being used with spring balances.

The Imperial boards are also used for experiments on "tension in cords," the pulleys being removed, or separate boards provided. It would be convenient to have 6 boards without pulleys. Small screw hooks, on which to hang the balances, will be necessary.

A simple model of a crane.—This consists of a base board about 24 inches by 9 inches by 2 inches, with an upright post about 20 inches long, 2½ inches by 1½ inches. An ordinary compression balance reaching to 14 lbs. by 1 oz. is fixed on a wood block in the angle between the post and base board; and the wood jib 22 inches long 1¾-inch by ¾-inch tapering, is hinged to the balance and is provided with a small pulley (in a screw shackle) screwed in the top end. From a wire shackle a cord is taken to represent the "tie"; the pull being recorded on a spring balance reaching to 8 lbs. by 2 ozs. The angle of the jib is altered by passing the cord through different screw eyes in the vertical post.

Simple roof truss.—Two laths of wood, 3 feet by 1½-inch by ½-inch, are fastened together at the upper end by a loosely-fitting bolt and nut; the lower ends being fixed to cross pieces about 7 inches by 2-inches by ¾-inch to give stability. A cord with a spring balance tying together the two ends represents the horizontal tie.

(The beam and lever for application of the funicular polygon are described under Moments.)

Centre of Gravity.

Two each, triangular, circular, and irregular shaped pieces of stout tin plate or thick cardboard, longest dimension about 10 inches; also 2 each pieces of wood board, 1-inch to 1¼-inch thick, shaped to oblong, triangular, and parallelogram, longest dimension about 12 inches; also 2 each square prisms, cones, and cylinders of wood and of same base and height (2½-inches by 3-inches base, 6 inches high)

For inclined planes the drawing boards already described can be used, weights being placed under one end to give the necessary inclination; or the friction boards can be used. Six sheets of glass about 12 inches by 5 inches will be required.

Moments and Levers.

Two hard wood levers, 3 feet to 4 feet long, 1½-inches by ¾-inch, top edge graduated into inches. One lever to have centred fulcrum and the other an end fulcrum. A simple fulcrum can be made with cone points and centres, and wood or metal bracket.

One 90° bell crank lever, of hard wood, with brass plates at joint and cone points and centres, with bracket on base board. Short arm of lever 4 inches, long arm 14 inches to 18 inches. Spring balance, 10 lbs. by 2 ozs., and screw with back pillar for adjustment.

One hard wood lever, 3 feet to 4 feet long, 1½-inches by ¾-inch, top edge graduated into inches, with screw eye at each end. Two circular balances, 15 lbs. by ½ oz., 6-inch diameter. Hooks for hanging balances to underside of shelf or to wall brackets.

Elasticity.

Testing Wires.—If verniers are used, then for each of 3 wires the requirements are, a simple wood or metal scale about 6 inches long, and vernier piece reaching to 1/100-inch or to 1/20 c.m. for clipping to fine wires, and two strong hooks in wall brackets or posts round which the measuring wire and testing wire can be twisted. A length of 20 inches from supports to vernier is convenient.

Young's Modulus.—Two wires arranged along longest walls of room. Ends of wires twisted round hooks in wall near ceiling or clamped to a bracket, wires passing round grooved wood pulleys 6-inches diameter and down to vernier and scale pin.

Beams.—For each of two beams, the requirements are two brackets or wood blocks abutting from bench or wall, with hard wood knife edges screwed on top face; a length of, say 6 inches, of metre scale screwed to wall or bench midway between brackets; a metal stirrup made of ⅛-inch plate with hole for hook of scale pan, and with wire pointer soldered to top edge. About 6 each wood strips for beams, say 3½ feet long, for 3 feet span, ½-inch by ¾-inch, ½-inch by ½-inch, ½-inch by ⅜-inch.

Friction.

Six boards of pine or of different woods, each 30 inches by 7 inches by 1¼ inches, with cross pieces on one side at ends and centre, and each with aluminium pulley fixed at one end, groove of pulley being for cord ¾ inch from surface of board. Six sliders of wood, each 9 inches by 6 inches by 1½ inches, and face half cut away in centre to 4½ inches wide, ½ inch deep. A screw eye in centre of one end of each slider ¾ inch from the face.

Six single pulleys (Gin pulleys) about 5-inch diameter of sheave, and cord.

Machines.

Cord pully blocks with an equal number of sheaves in top and bottom block; one with single sheave blocks, one with double sheave blocks, and one with three sheave blocks. A good size is to have 2-inch brass sheaves with grooves suitable for ordinary sash line.

One wheel and axle, turned from wood, wheel of 10-inch diameter, axles 5-inch and 3-inch diameter, and 4 inches long. Fix with central iron spindle, supported in wood bearings, on wall brackets. One single sheave pulley block with hook for cord.

One Weston's Differential chain pulley block of smallest size made. Length of chain for top block to be 7 feet from floor and bottom block to reach floor.

One tripod screw jack, 1½-inch diameter, frame of jack to be rigidly fixed to strong base board about 24 inches by 9 inches by 2½ inches, fixed head of screw to have wood pulley 6-inch diameter, loose head to have board about 9-inch diameter 2 inches thick for load. Small aluminium pulley as used for triangle of forces board to be fixed on wood pillar from base board at convenient height and distance for "effort cord."

For windlass, the smallest size single purchase windlass should be obtained: it should be fixed on wood framework about 2 feet from floor, the handle being removed and a wood pulley about 10-inch diameter for the effort cord fixed in its place.

APPARATUS FOR GENERAL USE.

Weights.—6 each of 56, 28, and 14 lbs., 12 each of 7, 4, and 2 lbs., 12 sets of 1 lb. to ½ oz., or 1 lb. to ·1 or ·05 lb. Half of the weights should be "bar weights" and half "ring weights."

Flat disc weights for use with hook rods are convenient for testing rubber rods or wires. They can be obtained in sets of 1 lb. to 1-10 lb.

Scale pans.—6 each of brass pans, 4-inch or 4½-inch diameter; and of tinned iron, 5-inch and 7-inch diameter; the pans having chains and hooks.

Spring balances.—12 small brass Sportsman's, 4 lbs by 1 oz., and 6 of 8 lbs. by 1 oz. Six improved spring balances, No. 1, 14 lbs. by 2 ozs. One Family balance, 7 lbs. by ½ oz., 5-inch dial, enamelled face. By giving instructions with order, the balances can be graduated to ·1 and ·05 lb., which is much more convenient than to ounces.

Rules.—6 wood metre scales, with inches and tenths on one side, metric scale on other side.

6 wood 12-inch rulers, inches and tenths, with one edge bevelled.

One spirit level (about 8 inches).

A supply of fine wire (about 1-32-inch diameter), iron, brass, copper; of silk cord, sash line, and thick card (millboard).

SPECIAL APPARATUS FOR DYNAMICS.

Atwood's machine.

Hicks' ballistic balance.

Apparatus for balls rolling down inclined plane and water clock with electrical connections.

Apparatus for centrifugal force.

Small balanced fly-wheel for energy experiments.

Simple pendulums.

NOTE.—When purchasing apparatus, teachers should satisfy themselves as to suitability and reliability.

(6.)—BOTANY.

THIRD YEAR SYLLABUS.

STUDY OF FLOWERING PLANTS ACCORDING TO ENVIRONMENT AND SEASON.

Method of Study. The method of study most suitable to become part of the daily life of the pupil is that which is based upon the relationship of plants to one another, to animals which affect their growth, to physical environment, and to the seasons.

Relationship of Plants to one another.

Plant associations, such as a forest and its undergrowth; a hedge and its climbers; a cornfield and its weeds.

Plants that grow singly in the district, that is, do not form colonies or definite associations.

Relationship of Plants to Animals.

Influence of mammals that prune by browsing, thus altering the external shape of bushes, trees, furze, and pasturage generally; similar action of rodents and other small mammals. Influence of insects that affect pollination, or that protect plants against the attacks of injurious insects. Influence of insects (both larval and fully developed) that injure plants, *e.g.*, the aphides on stems and leaves; and grub and wireworm at roots.

Relationship of Plants to Physical Surroundings.

Soil, moisture, temperature, and exposure including exposure to light and to prevalent winds) are the chief factors. Plant associations or societies are thus determined.

Plants specially associated with basalt, granite, lime, and other rock formations; with clay, loam, sand, or peat (turf) soils.

Plant societies in bogs, streams, and ponds.

Plant societies in pure sand, as on the dunes by the sea.

Plant societies noted under the relationship of plants to one another.

Influence of sea breezes; comparison everywhere between influence of sheltered and exposed situations.

DRAWING TO SCALE.

Students' drawings should be made to scale

Large plants may be drawn to scale of $\frac{1}{2}$, $\frac{1}{3}$, $\frac{1}{4}$, etc., to suit the size of paper in sketch book; but, in each case, the scale should be marked. When members of plants are drawn separately, they may be made to a scale of 2, 3, 4, etc., but, if possible, a uniform scale should be adopted for each plant; if it is necessary to show a stamen, seed, or other small part on a still larger scale, additional drawings should be made. In addition to the scale drawings a *memorandum of the actual measurements* should be given in the note-book.

TECHNICAL LANGUAGE.

With reference to the orders presented in the course, it may be explained that a knowledge such as may be obtained from a standard Flora is not required; the pupil is asked to make the simplest examination only so as to be able to say that one specimen has the characters of the rose, and another those of the daisy, and so on.

At the same time, the teacher is expected to demonstrate from actual specimens the characters to be studied in the classification of plants into orders; but the descriptions need not be burdened with superfluous technical terms when definite English terms are sufficient. It should be remembered that the study is one which may find expression in simple sketches which tell far more than the most accurate phraseology of the language.

EQUIPMENT

(*a.*) *For Class Purposes*—

A six-inch to the mile Ordnance Survey Map of the district in which the field excursions are to be made.

A Flora of the British Isles.

Flower pots, seed pans, and suitable potting soil.

An optical lantern and a set of slides.

(*b.*) *For Pupils.* (*Each pupil*)—

A pocket note-book for field purposes; a sketch-book and note-book combined for outline and diagrammatic drawing and notes of student's own observations; two black lead pencils (a B.B. and H.B.), water-colours; one or two brushes for water-colours (or coloured pencils will serve), a sharp knife, a pair of mounted needles, a pair of small steel forceps, a millimetre rule, and a double planoconvex pocket lens.

NATURE CALENDAR.

Pupils should be required to keep a diary of events, such as the fall of the leaf, the first frost, the first appearance of flowers, etc. Such particulars as daily temperature, general remarks as to weather, "dull," "bright," etc., should also be noted.

As the School Year begins after the summer holidays, the present course should be commenced in August or September. Early autumn is an exceptionally good time to begin a course on observational Botany, as the chief events in the life-history of a plant throughout its year's growth may be easily reviewed at this season.

Preliminary Lessons on Living Plants.

As a preliminary, however, a start may be made by selecting one particular plant and devoting a lesson or two to its study.

It is most important that the actual specimens used by the class be living rooted plants, growing under natural conditions or in pots. (It may be well to ascertain first by questioning what the pupils already know about a plant, and then to arrange or systematise this knowledge as a basis for further study).

Autumn Studies.

The pupils will be directed to observe and note the differences between that part of the plant's body which is in the soil and that part which is above ground; and by questioning and suggestion the class will be led to see that the *forms* assumed by the different organs are correlated with their environment and function.

(In these and the other lessons following, the necessity for *names* will constantly arise. Under such circumstances—that is, *when the necessity is really felt by the learners*—there need be no hesitation in making use of a suitable technical term.)

Study of Habit.

The study of a type will naturally lead to a comparative examination of other plants. If at all possible, these lessons should be given out of doors, where abundance of living subjects illustrating adaptability of form ("habit") to particular environment may be conveniently studied. In this connection the nature of the soil and conditions as to moisture, light, and shelter ought to be noted. The "habit" of different plants associated with one another in a marked off area ought to be worked out by the pupils.

Whenever possible attention should be directed to the sensitiveness of plants to certain external agents, especially to light pressure (as in twining and tendril-bearing plants), and to moisture; but all experimental work may be conveniently postponed until the early summer.

Advantages of Commencing Study in the Autumn.

After such preliminary work as the foregoing, the pupils may be led on to construct from direct observation, aided by obvious inference, the life history of a few typical plants throughout the changing seasons of the year. It will be found convenient to study in succession selected examples of the three great groups—Annuals, Biennials and Perennials (herbaceous and woody). At this season, fortunately, specimens may be obtained representing every phase of plant activity—seedling stage, period of vigorous growth and individual advancement, bud development, completion of seasonal growth and storage of surplus food, development of flowers, production and dispersal of seeds, preparation for winter's rest, and resting condition.

Study of Life Histories of Plants—Economy of Annuals.

Annuals.—Most of these have now passed into the "fruiting" stage, and it will be easily seen in such cases that growth has apparently come to an end. If, however search be made, annuals may be discovered at this season in all stages, from the seedling to maturity. Some will also be found with the seeds scattered and the plant dying. There should, therefore, be no difficulty in leading pupils to see that in annuals the early part of their season of activity is mainly devoted to individual growth and development, while the latter part is devoted to the production of young contained in seeds; and that after the dispersal of the latter the plant gradually dies.

Economy of Biennials.

The pupils may now be given the task of finding out the life-history of such a plant as the Turnip, Carrot, Hollyhock (or other type of Biennial conveniently at hand). At this period of the year it may be producing, or it may have already produced seed. Obtain plants only one season old and compare with those of two year old growth. Direct pupils to examine the root of the former and question them upon it. Sufficient evidence will be forthcoming to show that in Biennials the whole of the first growing year is devoted to individual growth and development and to the storing of surplus food in the root. Then there is a period of rest, after which the whole of the second year is mainly devoted to the production of young. During this period the reserves of food are withdrawn and used for purposes of growth. After dispersal of the seeds, the plant gradually dies.

Economy of Perennials.

Herbaceous Type.—In the same way lead pupils to interpret the story of the Perennial from what may be now observed in the field. Begin with an easily-studied herbaceous perennial. In the simplest cases (1) the flowering shoots have had the same history as annuals, but they are exceptional in that they arise from an underground stem instead of from a seed; (2) simultaneously with the growth above ground, new buds (for next year's shoots) have been developed underground; and (3) food has been stored in the permanent subterranean stem as a reserve for the spring use of the buds.

Woody Type.—Follow this up with the study of a typical woody perennial. Lead the pupils to discover and mark off on a selected tree the exact length of leafy shoot which they consider represents the result of the season's growth. (If such a tree as the maple, in which the twig ends in an inflorescence, is selected, it will be easy to compare the now fruiting branch with the annual plant and the shoot of herbaceous perennial previously studied. Pupils will readily recognise wherein it differs from the annual and agrees with the shoot of the herbaceous perennial.)

Note the formation of buds on the young shoot, and question pupils as to what they know concerning their nature and destiny.

When in the field or garden, draw frequent attention to the various methods of vegetative propagation such as bulbils, rosettes, runners, &c., and invite pupils to work out little problems in plant economy, such as :—"What becomes of duckweed during the winter?" "How do pondweeds hibernate?"

Review of Work and Comparison of Life Histories.

By much questioning and consultation of note-books, take the class over the whole ground of observation already recorded, and make the following facts quite clear :—

(1.) A plant is first of all concerned in building up its own body—that is, developing those organs that are directly concerned in its own welfare.

(2.) Having reached vegetative maturity, its chief concern is the welfare of the race, the continuance of which is secured by the production of young contained in seeds, or by the detachment of buds possessed of the power to lead a separate existence.

(3.) In plants that live for two or more years, further vegetative growth is secured for each year by the formation of buds that lie dormant during the winter.

(4.) In all biennial and perennial plants reserve food is stored for the feeding of the bud in spring, while in annuals all surplus food is stored in the seed.

Dispersal of Seeds.

The methods by which seeds are naturally distributed over the surface of the country ought to be, to some extent at least, studied at this period of the year. Once the pupils are interested in the matter they will make their own observations "out of school." Indeed, this is the kind of spirit that ought to prevail throughout the whole course. The pupils should be so thoroughly interested in the subject that they will always be on the alert to discover something new, and anxious to accumulate facts in their "Nature Calendar."

The Passage into Winter.

As autumn wanes, the leaves of deciduous trees change colour. The pupils should br encouraged to observe and note these changes. Leaf-fall is to be very carefully studied. By exposing the insertion of the leaf in section from time to time a few weeks in advance of the actual fall, the mechanical reason for defoliation will really be discovered by the pupils. The times of leaf-fall of the trees in the locality will be noted—(*a*) when the leaves begin to fall; (*b*) when the tree is bare of leaf.

The Beginning of Winter: Modes of Protection against Wet and Cold.

Winter Studies.

In early winter, close attention should be paid to the various methods adopted by plants to protect themselves against the trying effects of the weather, *e.g.*, the underground habit of main stem carrying the buds and containing the reserve food to feed these buds next spring; drying ("ripening") of twigs and protection of same by jackets of cork; covering of air-exposed buds often with dry tough scales; further protection by gummy secretions, &c., &c.

As the weather gets more severe, special attention should be given to the decay of the aerial shoots of herbaceous perennials, and to the protection these decaying members afford to the hibernating plant beneath.

A Winter Field-excursion.

During December or January the class should be taken out for a field-excusion and the vegetation studied at this, its period of lowest vital activity. Note, however, in sheltered places the large number of autumn seedlings making a brave struggle against the adverse conditions of existence.

Study of Dormant Underground Structures.

In the meantime some typical underground structures should be examined in the class-room. The following are suggested:—

(1.) Tulip or snowdrop bulbs and crocus corms. Each pupil to be supplied with three or four specimens of each kind; one of each kind to be thoroughly studied with dissecting knife and lens, and careful sketches made of the parts. Old plants showing the origin of the young bulbs and corms ought to be exhibited and demonstrations given upon them.

(If not done before, the iodine test for starch should be shown to the class. The pupils should thereafter be invited to discover whereabouts in the bulb or corm starch is stored, or whether, in fact, starch is present at all. Furthermore, if a microscope is available, starch-grains might be shown to the pupils in scrapings from the starch-holding tissues.)

Pot Culture for Bulbs, &c. for Convenience of Future Study.

After completion of above examination the class should be shown how to plant the remaining bulbs, &c., in pots or boxes of earth. Some so planted may be kept in the school, but pupils should be encouraged to plant duplicates at home and attend carefully to them until they pass into the flowering stage.

Sketches of the plants should be made at different stages of development.

Further Study of Underground Structures.

A rhizome and a tuber (potato will serve) should be examined externally, and in vertical section, and duplicates put down to "sprout." As in the last exercise, sketches should, of course, be made.

A biennial "root," such as turnip, carrot, evening primrose, &c., may be examined, sketched in vertical section, and a specimen planted in a box in order to study future development.

Special Points to note in the Study.

In all the above cases, particular care should be taken to see that the class clearly understands (*a*) the age of the structure, (*b*) the position and character of the bud or buds, (*c*) the whereabouts of the reserve food, and, if possible, (*d*) the nature of the reserve food.

The Twigs of Trees.—Study of these and comparison with Underground Structures previously examined.

Woody twigs may now be examined in detail with dissecting knife and lens. Let pupils sketch external features, showing shape and position of buds, &c. They should then be led to discover that there is a separable bark, covered externally with a thin layer of cork, and enclosing a cylinder of wood with medullary rays, connecting the pith with the bark. Direct pupils to study the connection between the buds and the supporting "wood" by cuts that split the stem and bisect the buds. Sketches should be carefully made, with the help of the lens, if necessary. It is important to let pupils discover the reserve food stores in winter twigs; the twigs of some trees show it (by the iodine test) very much better than others.

Resting Flower Buds.

Follow this work up by getting the class to examine twigs of early flowering shrubs or trees, such as currant, cherry, elm, etc. See whether they will discover the flower buds; it is very important that they should.

(Cuttings of willow and other twigs should now be placed in bottles of water to supply material for the study of the "opening of buds" in spring. Keep the bottles in the school-room.)

Study of Trees.

The foregoing exercise will naturally lead on to the study of *branching* in trees and shrubs; and this is the most favourable time of the year to begin. Pupils ought to be encouraged to learn to recognise trees by their winter appearance.

"Evergreen" trees and shrubs should have some attention about this time. The advantage of the needle-shaped leaves in pines may be indicated.

Examination of Planted Bulbs, &c.

Spring Studies.

Towards the beginning of spring the autumn-planted bulbs, &c., will have reached the flowering stage. Each pupil will carefully raise a specimen plant, wash the roots, and compare its present appearance with the sketches made of the same kind of "bulb," &c., in the autumn. By questioning, lead the class to realise that the flowering shoots have been feeding upon the stores of reserve food found to be present in the bulb last autumn, and to understand why the snowdrop, crocus, &c., are such early flowering plants.

Reasons for Early Flowering.

Study the flower itself with the class, and pay particular attention to the pollen-producing and seed-producing organs.

Exercise in Artificial Pollination.

Using the plants left untouched in plants or boxes, show the class how to pollinate the stigmas by means of a camel's hair brush, and then let each pupil pollinate a flower in the same way. Set the pollinated plants aside and let the pupils watch the gradual formation of the fruit. Sketches drawn to scale, and illustrating the development of the fruit, are desirable. The conditions of fruit development in the crocus will be an interesting variation from the normal.

"Home-work."—Watching the Bees pollinating early Spring Flowers.

Later, when the crocus and other spring flowers are open in gardens and on lawns, suggest to the pupils the exercise of watching to see how pollination is affected in Nature.

How the Microscope may be used with advantage.

If a microscope is available, pupils might be shown the pollen grains of the different plants examined. It will also give additional interest to this part of the course if a bee is caught, and the pollen found on its body examined under the microscope; the pupils should be asked to recognise the source of the grains.

Artificial Hastening of Twig Activity.

About this time, if not earlier, the twigs forced in bottles of water will be ready for study. Provide each pupil with a twig thus forced in its growth, and one taken fresh from the same kind of tree. Compare. Note difference in quantity of sap and, in particular, the ease with which the bark seperates from the wood in one of them. Introduce the word "cambium," and advise as to its meaning and importance. Question class as to the origin of the food upon which the young shoots are now feeding, and compare physiology with that of the bulbs and corms previously studied.

Examination of other Cultures.

Overhaul the other structures (tubers, roots, &c.), laid down to sprout, and if sufficiently advanced, distribute among pupils, and by questioning elicit their physiology of growth.

An Outdoor Class.

The beginning of spring is announced by the bursting of buds in our shrubs and trees. A bright day should be selected, and the class taken on a field excursion. Let pupils note all the "signs." A collection of twigs taken from different trees, &c.,

should be made, and in those with already opened buds the evidence of the flowing "sap' should be discovered.

Root-pressure and "Ascent of Sap."

Select a young tree or vigorous sapling, whose buds have begun to swell, and demonstrate to class the force of this spring run of sap by the usual root-pressure experiment.

The Evolution of a Shoot.

Once the bursting of bud has really set in, pupils should make a selection of one particular tree (maple is a good example), and prepare a series of sketches showing the gradual evolution of a twig from a bud.

The meaning of the peculiar ring-like scar seen at the base of the leafy shoots of trees will now be evident.

Seeds and Germination.

The study of seeds and germination will form a very important feature of spring work with the class. A series of types ought to be selected some weeks before they are really wanted, and a sufficient number sown in pots of fine earth, to supply specimens to the class.

(Attention must be paid to drainage and watering, and the pots kept in a moderately warm place.) It will be well, when studying a seed, to have a germinated specimen of the same kind in front of the pupil for comparison.

Physiology of Germination.

Some time and care should be given to the physiology of germination. The experiments need not be numerous, but they should be convincing. With the pots of germinated seedlings in front of the class, raise the question as to how seeds germinate, and discuss with pupils the particular methods of experiment that may be used to give accurate information upon the chief points raised. Experiments demonstrating the absorption of water, respiration including generation of heat, as well as the digestion and absorption of reserve food (as in the case of wheat seedings), may be mentioned as being very important.

"Home Work" : Systematic Observation of a Plant throughout its complete Life.

A number of annual plants might be carefully selected and seeds (1*d*. packets will serve) of same obtained. Each pupil might be invited to select a packet and to undertake to sow the seeds in a pot of soil, and to personally attend to the wants of the plant until it flowers and sets its seed. A written account of the pupil's observations during the season of growth might be required. Suggestions as to what to look for should be given to the class from time to time.

Spring-flowering Trees.

The study of early flowering trees must not be overlooked. Compare with early flowering bulbs and get pupils to refer to their notes and sketches of testing flower-buds studied in winter. Question as to reason why the flowers can be produced so early in the year, and whether there is any apparent advantage in their appearing while the tree is still leafless.

The class should be taken again out of doors for an excursion in late spring in order to note the outburst of leaf and flower buds and the progress in growth made by twigs and by the shoots arising from the underground structures of herbaceous perennials. Note should also be taken of growth in cultivated plants in field and garden.

Simple Experiments illustrating Phenomena of Plant Growth.

About this period simple experiments, devised for the purpose of illustrating some of the more striking phenomena of plant growth, might be undertaken by the pupils. Measurement of the rate of root and internodal growth; comparison of growth in light and in darkness; "sleep" movements, &c., may be mentioned as suitable experiment for this stage.

Gradual Passage into Summer. Field Work in early Summer.

Summer Studies.

During early summer attention should be directed to the behaviour of plants during growth, the distribution of the root in order to collect water, the placing of the leaf-blade so as to obtain the maximum amount of light, the means of checking loss of water by transpiration, the action of twining stems, and of tendrils, and kindred phenomena. Of course this information to be real can only be obtained by the class from observation in the field or in the garden.

Grand Period of Growth.

At this period of the year the majority of plants are growing fast; it is the season of individual growth and development, and will be immediately succeeded by the grand period of flowering, when the plant's vital efforts will be concentrated upon the production of young.

Reproductive Period of Plant's Activity.

Flowers have been noticed since early spring, and the pupils have been encouraged to note their appearance, but summer is the best time for detailed comparative study of them, and for lessons and exercises dealing with the rudiments of plant classification.

Plants other than Flowering Kinds.

It is suggested that pupils might be made familiar with the broad natural history characters by which the great groups of local vegetation may be recognised in the field—Flowering plants—ferns—club-mosses—"horse-tails"—mosses—liverworts—fungi—algae.

Examination of Flowers.

In the selection of flowers for detailed class-room study, care should be taken to include types of the great sub-divisions of flowering plants. The following list will serve as a guide :— Buttercup—wallflower—pink—flax—pea—rose—wild parsley—dandelion—potato—stinging nettle—pine.

The adaption to secure fertilisation ought to be studied in all cases.

No Teaching of Classification until Pupils have something to classify.

No attempt should be made to teach "classification" until all the above or similar types have been dissected, sketched, and described. When that is done, the class may be told the characters that botanists have selected as indicative of affinity among the series of plants, and the pupils' discrimination tested.

Literature.

The best text-book for teacher and taught is presented by Nature. The teacher will during his own studies meet with various books; but he should secure the most stimulating of all, Oliver's English edition of Kermer's "Natural History of Plants." The best book of reference for the pupil should be that which contains his record of the year's work.

FOURTH YEAR SYLLABUS.

Method of Study.

Small schools taking up the course in Botany may have the fourth year's pupils taught concurrently with the third year's pupils, provided the total number registered does not exceed twelve. Since a large part of the work consists in observations and experiments, and the recording of these by means of sketches and tabulation, one teacher may efficiently supervise the work of twelve pupils working the third and fourth years' courses concurrently.

A short demonstration to one set of pupils can be so arranged as not to interfere with the practical work of the other set.

Pupils of the fourth year will thus have an opportunity of revising the more important parts of the third year's course while they are performing the physiological experiments, many of which will require several weeks for completion. The chief advances made in this course over the third year's work are:—

1. The greater prominence given to experimental work.
2. The frequent use of the microscope.
3. The study of typical orders and practice in the use of Flora.
4. A fuller acquaintance with non-flowering plant associations in the field.

The teaching must be esentially practical. It is particularly desirable that field demonstrations should be given from time to time, and the pupils instructed in methods of observations and note-taking.

Each pupil should be required to record in a book specially kept for the purpose all the experiments and observations made by himself together with the date on which the experiment or observation was made. It is suggested that in all the experimental work some definite method of note-taking be adopted, such as :—

(1.) The problem stated; that is to say the object of the experiment.

(2.) The method adopted to solve the problem.

(3.) The result obtained and the answer it gives to the enquiry.

Sketches should be given whenever possible.

It is recommended that arrangements be made whereby plants may be grown in or round the schoolroom. Windows should be utilised for this purpose.

A number of flower-pots of various sizes, together with potting soil, will be required. Potting soil for general purposes may be made by mixing a fibrous loam (such as may be obtained from a good pasture or hedge-bank) with sand or road sweepings and a little soot.

Good drainage should be provided by placing a number of pot-sherds at bottom of flower-pot, over which may be placed a layer of fibrous material to prevent the soil from choking up the drainage. Attention should be paid to watering.

In the experimental work the pupils themselves should be required to fit up the apparatus, conduct the experiments, and record the results. The teaching should be directive and suggestive rather than demonstrative. The class should be made to feel the necessity for an experiment before it is set to work to perform it; the teacher should receive suggestions and encourage originality.

Teachers will use their own discretion as to the particular order in which the different subjects will be taken in class. It will be wise to look well ahead so as to have specimens available in suitable condition at the proper time.

NOTE.—*The following syllabus consists in the main of a list of experiments indicative of the character and scope of the work. The teacher must supply the logical thread required to connect the various observations and experiments together. The value of the course will entirely depend upon the ability, skill, and enthusiasm of the teacher in making any particular series of experiments and observations appeal to the imagination and intelligence of the pupil, thus enabling him to grasp the thread of the story which it is the object of the experiments to tell.*

Outdoor Studies. In addition to the work particularised below under "Recognition of Plants in the Field," pupils are expected to continue the outdoor studies (adding to the Nature Calendar) begun in their third year.

Seeds and Germination.

1. Study soaked seeds and seedlings (raised in pots of sand) of (*a*) bean, pea, or acorn, (*b*) buckwheat, ash, or wheat, and (*c*) radish, turnip, or mustard

Study of the Early Life of the Plant.

2. Devise experiments to demonstrate power of living seeds to absorb moisture, and to show that dry seeds are able to withstand extremes of temperature better than moist ones. Will seeds killed by drying absorb water as readily as living ones ?

3. Demonstrate as to influence of temperature upon germination.

4. Show by actual experiment—(1) that germinating seeds absorb oxygen and generate carbonic acid gas, and (2) that heat is liberated during this respiratory process.

5. Study the character of the food supply stored in the endosperm of wheat grains by making a mechanical analysis of wheaten flour, and testing the discovered albumen and starch. Demonstrate the presence of mineral matter (the ash) in a wheat grain.

6. At this stage let pupils cut thin sections from a potato tuber, or from the scale leaf of a lily bulb, and examine and sketch cells and their contents as seen under the microscope. Compare these with similar sections cut from a wheat grain.

7. Study sprouted wheat grains, and note especially the progress in growth made by the embryo and the difference in character of the floury contents of the grain. Test the milky substance for sugar. Examine the partially digested material under the microscope, and note the altered appearance of the starch grains.

Growth of the Seedling.

1. A variety of different seedlings should be studied. Observe in the case of maize, beans, buckwheat, &c., the gradual digestion, and subsequent transference, of reserve food to the seats of growth and recapitulate necessity for warmth, moisture, and respirable air.

2. Study a complete seedling of pea or bean (and sketch to scale) with soil particles attached to root. Note the difference in appearance between the growing points of the stem and the root.

3. Discover by experiment the elongating regions of root and shoot.

4. Selecting seedlings of such suitable plants as nettle, poppy, turnip, etc., examine the root system, first under a lens, and then the growing point and root-hair region under the low power of the microscope.

Observe the growing points of the young root-branches breaking through the cortex of the main root.

5. Conduct experiments to demonstrate irritability of root tips to (*a*) gravity, (*b*) contact, (*c*) light, (*d*) moisture.

6. Watch as closely as possible the development of the foliage

leaves and the gradual elongation of internodes in growing seedlings kept under healthy conditions.

7. Keep seedlings of buckwheat or mustard, some growing under normal conditions, and others in poor light, or complete darkness, and watch the gradual starvation of seedlings in the latter case.

The Plant Itself.

1. Selecting one or two types, carefully study in each the origin, arrangement, and form of the various organs concerned in the nutrition and development of the individual.

Period of Vegetative Development.

2. Examine leaf-buds, make out their structure, and follow their development into shoots. Study the formation of the root-system.

3. In a variety of selected plants make out the character and arrangement of the skeletal tissue, that is, the tissues that give mechanical support to the different organs.

4. Study, with the aid of pocket lens, the vascular system of some easily dissected stem, such as vegetable marrow or potato. Show the tubular structure of woody tissue by examination under a microscope. Sketch sieve-tubes as seen under the microscope.

5. Inject leafy shoot of potato with eosin, and trace ramifications of bundles in stem and foliage

6. Discover position of cambium in woody stems of different ages, and understand its function.

7. Arrange a series of experiments to illustrate the irritability of plants. In cases of movement of position, differentiate between the sensitive and motor region. "Sleep" movements and movements stimulated by contact are to be specially studied. Hygroscopic movements in relation to seed dispersal and seed-burying should also have attention.

How the Plant Lives.

Respiration—

1. Show by actual experiment with germinating seeds, bulbs, tubers, etc., and with opening flowers—(1) that living plants spontaneously oxidise, that is, they use up oxygen and give off carbonic acid gas, and (2) that heat is liberated during the process.

2. Importance of respiration to living beings.

3. Demonstrate presence of air in different organs of plants by immersing detached parts in hot water, and watching the escape of the expanding air. Discover presence of lenticles in twigs, and find, with help of a microscope, stomatal openings in the epidermis of leaves.

The Plant in Relation to the Soil—

1. Make a mechanical analysis of ordinary garden soil.

2. Ascertain percentage of organic matter present.

3. Take a very small quantity of the finer earth, spread it out on a glass slip and examine under a miscroscope. Now dry

the soil on the slip and again examine. Note the difference in appearance.

4. Examine under the microscope a living root-hair with soil particles attached. Seedlings raised in a pot of fine sand supply good material.

5. Devise experiments to show osmosis in a cell or a tissue—such as placing a rigid succulent tissue in a salt or sugar solution, and when limp restore rigidity by soaking in fresh water.

6. Set up a series of water—and pure sand—culture experiments in order to demonstrate the need of nitrates and certain minerals to growing plants.

7. Grow peas or other leguminous plants, raised in damp sawdust, in (1) pots of ordinary garden soil, (2) ordinary garden soil sterilised.

Note presence of root nodules in the one case and their absence in the other. Meaning and use of these root nodules.

Movement of Water in Plants—

1. Arrange experiments to demonstrate (1) root pressure, and (2) the lifting power of transpiration.

2. Selecting a suitable plant freshly removed from the soil, cut through the lower part of the main root and inject with eosin. Dissect the plant in order to follow the ramifications of the injected tissues and thus discover the position and character of the channels through which water is conducted from root to foliage.

3. Prove that water (in the form of vapour) escapes from leaves under ordinary conditions.

4. Examine fragments of leaf epidermis under the microscope and observe stomata.

5. Take a plant or part of a plant and discover the exact amount (both by weight and volume) of water lost in a definite time, being careful to note the existing external conditions that influence the loss of water in this way.

6. Ascertain by experiment if one side of a leaf loses more water by transpiration than the other.

7. Discover, by actual experiment, the atmospheric conditions that most influence the rapidity of transpiration.

8. Importance of transpiration to a growing plant.

Carbon Assimilation—

1. Preliminary experiments with leaves to demonstrate presence or absence of starch. (Sachs' iodine method.) Ascertain if the white or non-green areas in variegated leaves shows presence of starch.

2. Test for presence of starch (1) in leaf taken from a plant exposed all the morning to bright sunlight, and (2) in a leaf taken from same plant after being kept in darkness for twelve hours or so.

3. Devise a simple experiment with submerged water plants to prove that when a green plant is exposed to sunlight, and kept at a proper temperature, and in presence of carbonic acid gas dissolved in the water, oxygen gas will be liberated, and starch will make its appearance in the leaves.

4. Show that the evolution of oxygen ceases if the plant is (1) shaded, (2) chilled, or (3) kept without carbonic acid gas. Discover if oxygen is evolved under the influence of (*a*) blue light, (*b*) red light.

5. Grow a pot-plant under a glass bell-jar, taking care that all proper conditions of growth are secured, with one exception, namely, the absence of carbonic acid gas in the air within the bell-jar. Test the leaves for starch after exposure to strong sunlight for some hours.

6. Using a variegated leaf, ascertain if starch is formed in absence of chlorophyll.

7. Make out, under the microscope, the chief tissues of the leaf (1) the epidermis, (2) the soft, green, cellular tissue, and (3 the veins, and note especially the presence of chlorophyll bodies within the cells. Extract the chlorophyll from the leaf cells by means of alcohol.

8. Study the air chambers in the leaf.

Storing Reserve Food—

1. Examine unripe grains of corn, and taste the sweet contents. Compare with ripe grains and note differences.

2. Examine tubers, &c., for starch or inulin; carrot, or other roots, for sugar; and turnips, &c., for solid albuminoids; seeds for oil and granular albuminoids.

The Flower, the Seed, and the Fruit.

1. Conditions favouring the formation of flowers.

2. The parts of a flower. Examination of types. Construction of floral diagrams.

Period of Reproductive activity.

3. Detailed study of stamens and pistils, including a microscopical examination of pollen, and of artificially germinated pollen grains; of stigmas showing attached pollen grains (flowers of chickweed will serve), and sections of ovules, showing the egg cell.

4. Methods of pollination, natural and artificial; study of floral form and symmetry in relation to insects.

5. Ascertain by actual trial if fertility depends upon cross-pollination in particular flowers; discover cases where self-pollination is the rule.

6. How embryos are formed. Ripening of seeds and fruits. Study of fruits and dispersal of seeds.

Recognition of Plants in the Field.

During excursions the pupils of the fourth year should be introduced to the use of a school Flora, but at first under the guidance of the teacher, because of the large number of technical terms that seem to be inseparable from such books.

The Orders to which the list of plants given in the third year's course belong, are to be studied; and it is expected that the pupils will be able to recognise by reference to a Flora the native *generae* and species of these orders. No independent knowledge, however, of *genera* and species will be expected. In all cases, attention ought to be paid to *habitat*.

A lesson illustrated with exhibits of varieties, hybrids and double flowers will not be out of place, especially with regard to the interest of the pupil in garden flowers.

A general acquaintance with such groups of non-flowering plants as form well-marked associations likely to be met with in the field will be expected. Ferns, mosses, liverworts, mushrooms and other fungi, including lichens, seaweeds, freshwater *algae*. It is not necessary that the names of any members of these groups should be known, but that pupils, for example, should be able to recognise as a moss any member of the moss family. The particular *habitat* ot the plants ought to be noted in each case.

Homework.

In the third year it was suggested that pupils should keep a potted bulb under observation at home, and watch and record its growth and development during the season. Fourth year pupils might be given a somewhat similar task, only the selection of a subject might well be left to the individual fancy of the pupil. A tree is an excellent subject.

(7.)—PHYSIOLOGY AND HYGIENE.

NOTE.—This syllabus contains subject-matter for a two-year course of study in Day Secondary Schools, as follows :—

First-year Course.—Physiology, I., II., 1, 2, 3, 4.
Applied Physiology, Hygiene, I., II.
Second-year Course.—Physiology, II., 5, 6, 7, 8, 9.
Applied Physiology, Hygiene, III., IV.

The pupils of the second year are also expected to have a competent knowledge of the matter of the preceding sections.

INTRODUCTORY.

Remarks suggested by the structure of the human skeleton form an appropriate introduction to the study of Physiology. Note the division into the skeleton of the trunk and that of the limbs. The vertebral column, a canal continued into the cavity of the skull, serves for the protection of the nervous system which it encloses. It is also an axis for the general support of the trunk. Through the holes placed between the vertebræ the nerves pass out to the body to transmit the messages which put the central nervous system into communication with all the other organs. Strength and solidity in the supporting column are obtained by its fixation to the pelvis; adaptability to movement by the general plan of articulation. The light cage formed by ribs and cartilages assists in the formation of the trunk and serves to protect the heart and lungs. Next point out the plan of structure common to all the limbs, What advantages result from the loose attachment of the upper limbs? Why is the pelvic basin so strong, so firmly united? Then the smooth articular surfaces of the limb bones may be shown, and the range of motion possible in the several joints illustrated from the shape of the joint cavities. The pupil is now asked to consider how locomotion is effected. The muscles, as straps of contractile flesh passing from bone to bone, provide the immediate mechanism; but what excites them to act? The motor nerves come *from* the central system. Quite a different function is that by which the skin sends impulses *to* the central system. Finally, the nourishment and sustainment of the whole body is provided for by digestive and other organs placed in the cavities of the trunk; and by the vessels, which penetrate all parts, the heart sends the blood through all. The names of the bones of the limbs, the classification of the teeth, deformities, such as spinal curvature and misshapen chest, and a variety of general information can be dealt with in the lessons given on the skeleton.

PHYSIOLOGY.

I. ANATOMICAL STRUCTURE.

Kill a rabbit with chloroform. The brain should be removed at once and placed in strong spirit.

Dissection of a Rabbit.

To remove the brain: dissect away the skin of the head and then expose the brain by snipping away, with a bone forceps, the roof and sides of the skull, beginning at the foramen magnum and working forwards. Cut through the dura mater which lines the cranial cavity. Cut across the spinal cord half an inch behind the foramen magnum, and turn out the brain carefully from behind forwards with the handle of the scalpel. Identify the several nerve roots; cut through them in order. Leave the brain in the preservative for a few days and then dissect and examine the parts carefully.

Lay the animal on its back, and fasten it down to the dissecting board by pins through the limbs. Make an incision in the ventral surface of the body from the anterior end of the breast bone to the pubis. Make transverse incisions at both ends of the median one and reflect the skin on both sides fully. Open the abdomen by a deep cut in the middle line from the end of the breast bone backwards. Cut outwards for about two inches on each side behind the ribs and pin out the flaps right and left. You now see the following viscera:—Liver, stomach, small intestine, and part of the large intestine. Turn the alimentary canal over to right side and expose the spleen, kidneys, adrenal bodies, diaphragm, mesentery, and vermiform appendix. The pancreas with its duct, lies in the duodenal loop. Now note the bladder behind the pubis. Examine the bile duct which passes from the liver to the duodenum, and then follow up the portal vein to its entrance into the liver.

Carefully cut through the mesentery with scissors along the whole length of its attachment to the intestines, except at the duodenal loop. Lay out the gut on the dissecting board, and identify in order stomach, duodenum, jejunum, ileum, cæcum, colon, and rectum. The internal structure of the parts may be studied by slitting up portions of them and examining under water.

Now remove the alimentary canal, by cutting through the œsophageal end of stomach and through the rectum near pelvis, and also the liver. Trace out course of bile duct from gall bladder and liver to the duodenum. What are the lacteals? What is the lymphatic system?

Open the thorax by a transverse incision just in front of diaphgram; cut through the ribs along each side, and remove the ventral wall of thorax as a triangular piece, taking care not to injure the vessels and other structures beneath it. Identify and examine the following parts *in situ*:—thymus, heart enclosed in pericardium, lungs, diaphragm, pleura, œsophagus. Remove the thymus and carefully clean the base of the heart and the roots of the great vessels. Identify the several parts of the heart, and trace the great vessels so as to show their branches or tributaries, and course. Point out the terminations of the venus system in the auricles, the origin of the arteries in the ventricles of the heart. Follow the trachea and œsophagus through the neck. Show the termination of the trachea in the larynx, of the œsophagus in the pharynx.

The thyroid gland may be seen on the sides of the trachea. The submaxillary (salivary) gland will then be found near the lower jaw.

The brachial plexus of nerves are next investigated as they enter the tissues of the fore limb in the axilla. The muscles of the fore limb are to be exposed by dissecting off the skin, and the mode of origin and insertion of one or two muscles may be demonstrated.

The kidneys still remain on the posterior abdominal wall, and may now be studied.

The rabbit is now to be turned over on its ventral surface, the skin removed over the dorsal and lumbar region, a deep cut made into the muscles of the latter region on each side of the vertebral column, the flesh cut away, and the vertebral arches carefully snipped and removed to expose the spinal cord.

The course of the principal arteries, carotid, temporal, subclavian, axillary, brachial, radial, palmar, femoral, should be pointed out on the chart of the human body. A knowledge of their positions is essential when one has to stop hæmorrhage in an emergency.

II. PHYSIOLOGICAL FUNCTIONS.

The activities or functions carried on by the living body are described under the following headings :—(*a*) Digestion, (*b*) Circulation, (*c*) the Blood, (*d*) Respiration, (*e*) Excretion, (*f*) Temperature, (*g*) Movement, (*h*) Nervous System, (*i*) Vision and other sensations.

1. Digestion.

The study of digestion should be preceded by a description of the chemical constituents of the animal body. The principal organic compounds of plants and animals are proteids, carbohydrates and fats. Show that proteids contain nitrogen, as well as carbon, hydrogen, and oxygen; that they are absolutely essential for the formation of living matter, because found in every cell, while carbohydrates and fat, without nitrogen, are of secondary value to proteid. A brief lesson on the composition of animal and vegetable tissues will enable the pupil to appreciate the principal facts of physiological chemistry, and grasp the reasons for the selection of our ordinary food stuffs. This introduction may be accompanied by practical demonstration, somewhat as follows :—

Proteid.—Presence of nitrogen shown by heating dried white of egg with soda-lime. Presence of carbon by charring.

Take white of egg, chop with scissors, dilute with ten volumes of water, and beat it up well to make it fluid; filter. To the filtrate apply the following tests :—

1. To a small quantity add a few drops of strong nitric acid; precipitate forms. On boiling, it turns yellow; add ammonia carefully till it becomes orange (xanthoproteic test).

2. To a small quantity of the solution add an equal volume of a strong potash solution and then one drop of sulphate of copper, one per cent. strength. The fluid becomes violet (biuret test). Perform a control test on water and compare result.

3. Add a few drops of Millon's re-agent (impure nitrate of mercury); precipitate forms turning red on boiling. Other reactions may be shown by coagulation with heat and by precipitation by corrosive sublimate.

Varieties of Proteid.—The chief proteid in white of egg is egg albumin. A somewhat similar proteid, serum albumin, is found in the plasma of blood. The presence of this albumin and of another proteid (globulin) may be demonstrated in serum of ox blood (obtained from a butcher).

Method.—First demonstrate the colour reactions given above on a portion of this blood serum. Separate the two proteids in another portion by saturating the fluid with magnesium sulphate; precipitate of globulin forms. Filter to remove it, redissolve it in water to which a little of the salt is added, try colour reactions on this solution, and note results. Heat the filtrate and note results. The albumin, which was not thrown down by the salt, coagulates. The presence of similar proteids in bread may be demonstrated by extracting wheaten flour with

10 per cent. sodium chloride for some hours. Apply same methods and note results. Similar experiments may be performed on the meal of maize and pea. Milk may now be investigated. The whey of milk responds to the colour reactions showing the presence of milk albumin. The principal proteid of milk, caseinogen, is present in large quantities in uncurdled milk. To the latter add acetic acid, and warm, or saturate with magnesium sulphate and shake vigorously, a precipitate of caseinogen (and fat) falls, leaving whey. The composition of lean meat or muscle may then be examined.

Can a proteid in solution pass through an animal membrane? Test this, using a piece of dried gut of a young animal (pig). Diffusible and indiffusible substances can now be described. What is a peptone?

Carbohydrates.—Why so called? Demonstrate absence of nitrogen. They are charred by heat, carbon is present.

The chief examples are starch, grape-sugar or dextrose, maltose or malt-sugar, milk-sugar, and cane-sugar. Compare the solubilities of these substances in water. Next investigate their response to the application of a weak solution of iodine. Then try the reducing reaction with copper salts in the following manner:—Dissolve some grape-sugar in water. Take a little of the solution in a test tube, add an equal quantity of strong potash and one drop of sulphate of copper solution of one per cent. strength. Boil. What is the yellowish red precipitate which is formed? (Refer to the application of the same reagents in a different reaction for proteids.) Next show how starch, or cane-sugar, not giving the reducing reaction, may be turned into a reducing sugar by boiling for some minutes with a little strong hydrochloric acid. Next try if the starch will pass through an animal membrane, repeating the experiment as performed for proteid. Is grape-sugar diffusible? The presence of starch in potato, wheaten flour, and other food stuffs may be easily demonstrated by means of the iodine reaction.

Demonstrate the action of yeast on grape-sugar and refer to the use of yeast in the formation of alcohol and in the baking of bread.

Fats.—What do they contain? How does paraffin oil differ from such an oil as olive oil? Take olive oil and lard, try their solubility in water, ether, choloroform, boiling alcohol. Next show the formation of an emulsion by adding a little potash to water mixed with the oil. What is an emulsion? Look at it under the microscope with a high power. Examine milk with the same magnification. The fat of milk may be separated by shaking a mixture of milk, ether, and some strong solution of soda in a stoppered bottle. The etherial solution comes to the top and it may be removed. The ether is allowed to evaporate and the fat remains.

Gelatine.—Gelatine is nearly related to proteid. It exists as collagen in fibrous connective tissue and in the animal matter of bone. The composition of bone may be shown by placing a piece of the fresh bone of a rabbit in weak hydrochloric acid for a couple of weeks until it is soft enough to be penetrated by a pin without resistance. The calcareous matter is thus removed. The soft bone (animal matter mainly collagen) is now subjected to prolonged boiling, and jelly or gelatine is formed. It is recognised by its jelly-like state in the cold. Is gelatine able to replace proteid in the dietary?

2. The work of Digestion.

What is the object of digestion? To make proteid, carbohydrate, and fat capable of absorption through the lining membrane of the intestine into the blood vessels which run in its wall. Mention the agents, enzymes, by which this is accomplished, the fluids in which they are contained, and the glands connected with the alimentary canal by which they are formed. Describe the results of their action on the food stuffs, and demonstrate as follows :—

For Carbohydrate.

Saliva (*Ptyalin*). (1) Boil starch with water; when cool add saliva, and keep at a temperature of 100 degrees F. some minutes. Now test for the presence of a reducing sugar.

Pancreatic Juice. (*Amylopsin*). (2) Perform a similar experiment with a preparation of pancreas extract obtained from the chemist.

(*Diastase*). (3) Another experiment with the vegetable enzyme contained in malt extract. What use do plants make of this ferment? What is the first stage of brewing?

For Proteids.

Gastric Juice. (*Pepsin*). (4) Mix solution of white of egg with one half per cent. hydrochloric acid, add glycerine extract of the stomach, which contains pepsin. Keep at a temperature of 100 degrees F. for a few hours on a water bath.

Note results by the following tests :—

Pancreatic Juice. (*Trypsin*).

(*a*) Does it coagulate on heating?

(*b*) Why does it give a pink colour with potash and copper sulphate, not a violet?

(*c*) Test its diffusibility through a piece of dried gut.

(5) Make a similar experiment with white of egg solution dissolved in 1 per cent. sodium carbonate solution, to which you have added extract of pancreas, and note results as before. Why must the former solution (4) be acid, the pancreatic solution alkaline? Next keep the digestive mixtures (4) and (5) for a day or two. Why does putrefaction occur in (5), not in (4)?

(6) Peptonize milk with pancreas extract.

(7) Demonstrate curdling of milk by the addition of rennet extract, placing on the water bath at a temperature of 100 degrees F. for some minutes. What is cheese?

A control series of experiments may be carried out in each of the above cases by boiling the fluid immediately after the addition of the solution containing the enzyme. This type of experiment may be applied to other kinds of food stuff, such as hard-boiled white of egg, bread, fibrin, gelatine, small pieces of muscle, and the formation of the diffusible products demonstrated.

For Fats.
Pancreatic Juice.

Fat splitting action of enzyme in pancreatic juice. Formation of emulsion with pancreas extract and sodium carbonate.

Bile.

The action of bile as a feeble emulsifier of fats may be shown.

Intestinal Juice.
For cane-sugar.

Illustrate its action on cane-sugar by the similar action of hydrochloric acid and boiling.

The general description of digestion may then be given, supplemented by special reference to the teeth, the peristaltic movements of the canal, the use of the lacteals and the portal vein for absorption of food stuffs, and lastly, intestinal putrefaction.

3. Circulation.

The dissection of the heart and blood vessels will have suggested the chief questions of interest, and provided an opportunity for an explanation the general principles of the circulation. Practical work may be outlined as follows :—Show the automatic action of the heart in a frog which has been killed and pithed. Show the blood stream in a living frog by spreading out the web of the foot under the microscope, and examining with a high power. The presence of pulsation in the arteries and its absence from the veins may be seen by reference to the vessels of one's own fore arm. Attention should be specially directed to the capillaries and to the mode by which fluid transudes through their walls into the surrounding tissues. Pressure, velocity, and the general difference in structure and function between arteries and veins may then be described. Manometer or pressure gauge, shown by a U-shaped tube containing mercury, and the mode of demonstrating blood pressure illustrated. The pressure is great enough to carry on the flow even against gravity. But if the heart is feeble or the system lowered, gravity may be sometimes a useful help. Hence a fainting person should be laid on his back.

The nervous control of the blood vessels may be explained in connection with the occurrence of blushing.

Blood.—The general description will include an account of the cells and the fluid or plasma, their composition and functions. Practical work. Examine a drop of blood under the microscope with a high magnification. Note the form of the cells, their colour in thin layers, and where massed together. Compare a drop of frog's blood. Note the difference in the shape and structure of the red cells. The white cells are more easily seen here. Receive a little blood from the heart of a rabbit, just killed, into a small beaker, stirring the blood with a bottle brush as it flows. This leaves the blood fluid while rapidly removing the fibrin. Shake up some of the blood in a test tube; note its scarlet colour due to the colouring matter, hæmoglobin. It is now chemically united with the oxygen absorbed from the air. Add a few drops of ammonium sulphide and warm gently; what change of colour occurs, and why? Arterial and venous blood can now be referred to, and the function of the red corpuscles as oxygen carriers from the lungs to the tissues described. (3) Receive some fresh blood from the heart of a rabbit, just killed, into a solution of potassium oxalate half per cent. strength; the oxalate prevents coagulation Why? Receive another portion into an empty test tube, it clots immediately, at first becoming a jelly. Lay it aside for twenty-four hours, and now note the soft red clot floating in a clear fluid, the blood serum. Experiments may be made on the oxalated blood to show how the presence of lime salts is essential for clotting of the blood. What is fibrin? How does clotting help to stop bleeding?

Carbon monoxide poisoning.—Take a test tube, half fill with defibrinated blood, connect an india-rubber tube with the gas pipe and put the free end of the tube into the blood in the test tube. Turn on the gas until it saturates the blood. What change in colour occurs? Why? Then refer fully to the danger of poisoning by carbon monoxide. How is the carbonic acid gas of expired air held in the blood?

The description of the phenomena of the circulation should be followed by a brief reference to the lymphatic system.

4. Respiration.

Kill a rabbit with chloroform. Carefully dissect the wind-pipe in the neck, ligature it so as to effectively close the tube. Now by careful dissection down to the ribs and breast-bone, and then by opening the chest cavity show that the lungs distended come close up to the chest wall. In a second rabbit show that if the chest is open without the precaution of ligaturing the wind-pipe the lungs collapse on penetrating the thoracic cavity. Remove the lungs and wind-pipe in one piece in the case of the second rabbit, and show by injection of air into the wind-pipe that the lungs can be very much distended. Show that when collapsed they still float in water. Now refer the pupils to the walls of the chest cavity, forming a cage of light ribs and cartilage, with muscles intervening and floored by the muscular diaphragm. Describe the pleura, and by reference to the experiments performed, show how the lungs are always in a state of distension during life, increasing with the active increase of the chest cavity during inspiration, diminishing with expiration. The lungs are therefore passively made to follow the movements of the chest walls as long as the pleura are intact. What excites the muscles of respiration to act? Where is the nervous centre which controls them? How many times per minute do respirations occur in man? The chemistry of respiration is then considered, the composition of air, the outgoing air, the amount of tidal air of ordinary respiration, the capacity of the chest, and the degree to which the air of expiration modifies the composition of the air of the room in which one lives are fully explained. The properties of hæmoglobin as an oxygen carrier may be described, and the affinity of the hæmoglobin for the poisonous carbon monoxide may again be demonstrated. Where does the oxygen go to? Where does the carbon dioxide come from? Is the oxygen held in the blood like air in soda water?

5. Excretion.

In the dissection of the kidneys the arrangement of the blood vessels and duct (ureter) may be investigated. The minute structure in branched tubules, and the disposition of the blood vessels to promote filtration through one portion of the tube, and the more special selection of chemical substances can be described. What happens after removal of both kidneys from a living animal? Name the principal ingredients removed from the body by the kidneys.

The sweat glands, sebaceous glands, and hair will be described in connection with the several functions they discharge. How much water is removed from the body by the skin, the lungs, the kidneys, in 24 hours? How is heat lost through the skin? How far does suitable clothing regulate its loss?

6. Temperature.

Where is heat produced in the body? How is it removed from the body? How is the temperature kept constant in man? What is the meaning of fever? What is the value of the several fabrics used for clothing as heat conductors? How is the temperature of the body taken with the clinical thermometer? What is it in the axilla? In the mouth? What is the value of woollen clothing as an absorbent of perspiration? What is the danger from cotton and linen in profuse perspiration?

7. Exercise.

The growth and increased facility of muscles for their proper movements may be taken as the explanation of the value of training in athletics, and the usefulness of habitual exercise. As one learns to write by practice, so by regular exercise all movements are accomplished with more facility. Need of exercise for the muscles of the back in young children to prevent spinal curvature; freedom from constriction of the chest requisite for normal respiration.

Show that the three orders of levers are exemplified in the actions of muscles, flexor of forearm (biceps) 3rd order, extensor of forearm (triceps) 1st order, standing on tiptoe (calf muscles) 2nd order.

8. Nervous System. Illustrate the general principles by a series, such as the following:—Voluntary movement, tactile sensation, reflex from the sole of the foot, and automatic control of movements of respiration.

9. Vision. A rectangular box without a lid, into one end of which is fitted a lens like a watch glass, is a useful piece of apparatus for demonstration. Place within the box a moveable bi-convex lens and a piece of flat dull glass to represent the retina. Fill the box with water and show the formation of images of a gas flame. What is the pupil? The cornea? The lens? The retina?

APPLIED PHYSIOLOGY, HYGIENE.

I.—MAINTENANCE OF HEALTH

IN RELATION TO WATER, AIR, FOOD, INFECTION AND ALCOHOL.

Water. Water as a solvent. The rain falling on the soil and percolating through it will receive a great many substances into solution before it re-appears in springs, wells, rivers, &c. Drinking water contains traces of many such substances, ordinarily not in quantities injurious to health. Name them. Hardness, a very simple deviation from the average by presence of too much lime salts. What salts may be injurious if conveyed through leaden pipes? Great dangers—that of organic impurities from decomposing animal matter, and infection. How far are we helped in the recognition of such materials by taste, colour, odour, sediment? Show that these properties may have no necessary relation to the presence of dangerous organic impurity in water. Where ordinary filters fail to remove infective microbes, boiling, a simple but effective means of doing so. Practical work should proceed as follows:—

Chemical Substances in Solution.—(1) Show the presence of chlorine in ordinary drinking water by means of silver nitrate. (2) Make up Nessler's re-agent, namely—solution of mercuric iodide in potassium iodide with the addition of an alkali. Demonstrate its value in detecting ammonia. What does a marked ammonia reaction in natural water indicate? (3) Hardness, temporary and permanent. Add 10 grammes of Castile Soap to one litre of dilute alcohol (35 per cent.). Take 100 cubic centimetres of water, add a few c.c. of the soap solution. Note precipitate. Then shake, and study formation of a lather. To distinguish permanent from temporary hardness, measure 250 c.c. of water; boil for half an hour: when cool pour off supernatant fluid so as not to disturb sediment, and treat the filtrate with the soap solution (one c.c. soap solution is equal to one milligramme carbonate).

Sediment.—Describe the different kinds of filter and construct a simple filter with a clean flower pot and gravel, sand, &c. What is a Chamberland filter?

Examine the sediment of pond water under the microscope. Note the presence of various animal and vegetable forms.

Demonstrate the use of Condy's Fluid. Explain its action. The subject matter of water contamination explained, the attention of the pupil is directed to the supervision which must be exercised in relation to the selection of a source of supply: its protection from contamination ; distribution, storage ; quantity of water per head for daily use ; and the final disposal of waste water.

Air.

The composition of air, and the modifications due to animal respiration have been already given. Other conditions modifying the atmosphere are suggested by cloud, smoke, dust, and the various impurities arising from the surface of the earth. The general principles of its purification—diffusion, winds, rain, and sunlight—naturally follow. The value of oxygen, essential to life, is next referred to. Under ordinary circumstances danger does not arise from want of this gas, but from the accumulation of impurities in enclosed places.

The chief impurities are:—

Chemical.—(1) The air of expiration, carbonic acid gas; (2) carbonic acid gas from other sources, such as pits, deep wells, brewery vats, sewers; (3) from carbon monoxide, escaping by leakages from gas pipes, or accumulating from imperfect combustion.

Mechanical.—(4) Minute solid particles, wood, coal, or metal in the air of factories.

Infective.—(5) Disease-producing microbes arising from centres of infection.

The air of respiration becomes unwholesome when the carbonic acid gas accumulates to about twice the normal amount contained in the air. Show that this, in rooms, necessitates a space of 1,000 cubic feet per head with ordinary ventilation. Demonstrate the presence of carbonic acid gas in the air of expiration by means of lime water. Next employ a 10½ ounce bottle, containing half an ounce of lime water, to determine if the air in a room has more than its normal amount of carbonic acid gas. Show the poisonous action of carbon monoxide by experiment referred to in the section dealing with blood.

Ventilation.—Simple experiments showing diffusion of gases; illustrate one mode of purification. The influence of heat causing air to expand and become lighter is also easily shown. Winds are large movements of the air determined in the same way. This leads to the use of the chimney as the natural ventilating shaft in the room, the window the natural inlet. What is the best mode of ventilation by the window, by lowering or by raising it?

Special modes of assisting ventilation are best illustrated by models of Tobin's tube, Sheringham valve, a louvre, a cowl and Hinckes Bird's block. For very large buildings—artificial ventilation.

Food.

The essential ingredients of food stuffs are proteids, carbohydrates, fats, salts, and water. Dietary includes, besides these indispensable nutritive materials, various accessories, such as condiment, and stimulating beverages, as tea, coffee, cocoa. Food stuffs are only rarely consumed in their natural condition. When cooked the danger of infection is mostly taken away, and food stuff made much more palatable. The true indication of the amount and quality of food we require is found in the amount of carbon and nitrogen removed from the body as waste. The carbon is to the nitrogen as 15 to 1. In proteid the carbon to the nitrogen is 3¼ to 1. The difference in carbon is made up for by taking carbohydrates and fat which contain no nitrogen. Animal food stuffs contain proteid and fat, vegetable stuffs mainly proteid and carbohydrate; hence the mixed diet. What is the average proportion of these in a physiological diet? Give a mere subsistence diet; a diet for very hard manual labour? Economy is attained by the selection of food stuffs which contain large quantities of these three ingredients. Is the diet of an agricultural labourer, if mainly derived from potatoes, economical? How would it compare with a diet mainly consisting of oatmeal? Show the value of the principal food stuffs, animal and vegetable, by a table giving their percentage value in proteids, carbohydrates, and fats. Practical work on food stuffs should be directed chiefly to the recognition of the ordinary appearances which indicate that food is wholesome. (1) Meat—its touch, consistence, colour, smell, distribution of muscle fibre, of connective fibre and fat in a piece of good beef or mutton. (2) Egg—the weight of an average hen egg; determine if fresh or stale by dissolving in a pint of water two ounces of salt and testing if the egg floats in the solution. (3) Milk—its colour, taste, amount of cream outstanding, amount of sediment, specific gravity, microscopic appearance. (4) Fish—its odour and colour. Does fish require to be heated as much as meat in cooking? (5) Wheaten flour—knead in muslin bag under water; show the presence of gluten. What is this substance? What is its value in baking? How is baker's bread made with yeast; with baking powder? (6) Butter—What is margarine? (7) Tinned foods—How prepared? (8) The dietetic value of green vegetables, of fruit. (9) The making of preserves. (10) The use of rennet in the production of cheese.

Beverages.—What is soda water? Why does it effervesce when the cork is removed? Tea, coffee, cocoa. Their active principles, their stimulating action. Presence of tannin in tea. The food value of cocoa. What is chocolate? What is an infusion? What is a decoction? Overdrawn tea, excessive consumption of tea.

Cooking.—A general account of the methods.

Adulteration.—Milk taken as an example, and discussed ully.

Disease-producing food to be suggested by putrid meat, shell fish from stagnant water, worm infected pork, and, most insidious of all, microbe-infected milk.

Infection.

What are microbes? What is their natural home? What are the natural agencies by which they are destroyed? Why is the air of the sea and mountains so pure? Show that some microbes are not disease-producing, though active chemically; instance the souring of milk. Show that jelly exposed to the air for some time becomes covered with microbic growths.

The action of antiseptics boracic acid carbolic acid, formalin, corrosive sublimate, may then be referred to. Now enumerate the diseases caused by microbes, and show that milk, water, air, earth, are ordinary vehicles by which they enter the body; that the ejecta, sputum clothing of infective patients are common modes of transmission. General methods of dealing with microbic infection—(1) prophylaxis or preventive treatment *e.g.*, vaccination; (2) isolation of patients; (3) use of antiseptics, of modes of sterilisation. Among antiseptics, boracic acid suitable for popular use in wounds, injuries, &c.; carbolic acid and corrosive sublimate powerful but requiring caution, as they are strong poisons. Boiling to sterilise utensils, steam for clothing. What kinds of disinfection are best for rooms, sputa, ejecta. Deodorisers, *e.g.*, quick lime, for removing the smell of putrefactive material. Do they sterilise?

Alcohol.

The common use of alcohol necessitates special consideration rather than inclusion as an item among the beverages classified under the heading, food. That it is an intoxicant is a clear indication of its poisonous properties. That it is of some value as a condiment, taken in small quantities with meals, when digestion is feeble, many medical authorities admit. It has also considerable value in phases of disease, but a doctor is the only person competent to determine such conditions. That, as used by the great majority of even sober people, its influence is rather in the direction of harm than of health, is generally true.

What is its composition? Why is it inflammable? How is it made? Its consumption is brought within the limits of safety only by large dilution with water. Strong spirits, such as whiskey, should be diluted with at least six times its bulk of water. Alcoholic drinks, if taken at all, should be consumed only at meals, and then with caution. Alcohol contra-indicated when active exercise is being taken; dangerous if one has to endure prolonged exposure to cold. Alcohol is most injurius to growing children. Classify alcoholic drinks, *i.e.*, beer, wine, spirits. Give a table showing their percentage composition. General rule—the more largely diluted, the safer. Show that alcohol precipitates white of egg from solution, and mention the diseases caused by its use in excess.

II.—PERSONAL HYGIENE.

The Teeth.—The necessity of taking as much care of the teeth as of the hair. The injury to teeth in children from excessive use of sweets, unripe fruit, &c. Need of yearly examination by the dentist.

Alimentary Canal.—Constipation; its common causes, want of sufficient fluid in diet, want of exercise and air. Habitual constipation in young girls producing anæmia, &c.

Respiration.—Avoid tight clothing, such as tight lacing. Remember the air passage begins at the nose, not the mouth, and that respiration should be carried on through the nose. Active exercise needs full and free respiratory movements, and should be carried on in the open air or in a well ventilated place.

Exercise, Rest, and Sleep.—Apply the physiological principle that the nutrition and growth of muscle are promoted by their activity, diminished by want of exercise. Too much exertion determines fatigue, and the muscles and other tissues require rest for their restoration. Sleep—the natural rest for all the organs. For the child, for the hard-working, sufficient sleep a prime necessity. Ventilate the bedroom. In active exercise the heart's action greatly increased. Avoid strain. Out of breath an indication for cessation of active exercise.

Habit.—Regularity in meals and in sleep. Daily evacuation of the alimentary canal. Children warned against the danger of cuts and open wounds in dirty hands. Cigarette smoking in the young a dangerous habit—injurious to throat and lungs. Inhalation of tobacco smoke pernicious. A good habit—modify the dietary occasionally.

Cleanliness.—The skin; an active excretory organ requiring frequent cleansing. What is the composition of a soap? Irritant and non-irritant soaps. How does soap cleanse the skin? The bath, besides its cleansing effect, is a tonic. Where a bath cannot be taken sponging with woollens or sponge a useful substitute. What temperature should a cold bath have?—What temperature for a warm bath?

How long should one stay in the bath? The temperature of the sea-water in summer, a standard for the temperature of a cold bath.

Clothing.—Good conductors, bad absorbents; danger of chill. Bad conductors, good absorbents; their value for the system enfeebled in anyway, for the young, and for those who take active exercise. Why is loosely worn porous woollen material warmer than close fitting stuff? Injury caused by clothing which constricts the chest and abdomen. Ill-fitting boots.

Preservation of Sight.—Short sight or myopia; easily recognised by comparison with the sight of another person. Long sight, hypermetropia. Is the sight rendered painful after study for a period of an hour or more? Astigmatism.—Take a white paper on which vertical and horizontal lines are drawn in ink. Place this paper on the wall, and look at it at a distance of

18 feet. Are the lines equally distinct? All three conditions necessitate the use of spectacles. Colour blindness.—Take a number of skeins of woollen thread of a great variety of colours and match the colours which resemble one another. Note defect as regards reds and greens. In what occupation is colour blindness dangerous?

III.—HOUSE HYGIENE.

Site.—In relation to soil, elevation, and sunlight.

Air Supply.—The value of fireplaces and of open windows. No bedroom should be without a chimney.

Heating.—The wasteful grate. The economical grate.

The Watercloset.—Its water supply; the trap; the course of the soil pipe; the drain; their ventilation. Danger of sewer gas. What is the dry-earth system? Is there disconnection of drinking water supply, and water supply to the closets?

Sick Room.—Inadvisability of curtains, carpet, dark corners, dust. Advantages of iron bedstead, hair mattress, light and warm coverings; necessity of uniform temperature, and use of a room thermometer.

Sick Nursing.—How to make the bed. Washing the patient. How to measure medicines. The capacity of a teaspoon—a tablespoon. Care of bed sores. Disinfection.

Lighting.—Oil, gas, the incandescent burner.

The Bath.—Its utility. Its situation. Simple substitute for it in small house

IV.—FIRST AID TO THE INJURED.

In part an application of the general principles of physiology; thus, artificial respiration, compression of principal arteries, the placing of a fractured limb in the position of rest with the least movement of the fragments, keeping a fainting person in a horizontal position, are cases in point. The use of simple remedies is, however, required in most cases. Whenever the surface of the skin is broken, microbes may enter the system. The treatment of the wound by an antiseptic should be employed. Poultices, fomentations, blisters, substances to produce vomiting, should be known to everyone. As a popular antiseptic the value of boracic acid powder may be pointed out. No household should be without this simple aid. The cyclist should always have it.

Practical Work.—To make a poultice. Have boiling water ready, put the linseed meal into the boiling water and stir till it makes a thick paste. Spread on linen, leaving a margin of one inch free from paste; turn over when the requisite amount of matter is spread on. If the linseed is not convenient, a poultice may be made from bread from which the crust has been removed, by soaking the bread in boiling water repeatedly and mashing to a pulp. The bread should retain its heat for an hour, linseed an hour and a half, or more. Bread is used for small applications, linseed for large. To make a turpentine stupe or fomentation—wring a cloth dry out of boiling water, and spread the turpentine in drops over the steaming surface.

A Mustard Plaster.—Mix the mustard with cold water, and spread on brown paper; when taken off the patient, remove the mustard carefully from the skin.

To Produce Vomiting.—Two tablespoonfuls of common salt in a tumblerful of water, or mustard and water.

Fainting.—Horizontal position, open the clothing over neck and chest, simple external stimulants (cold water, smelling salts).

Fits.—Infantine fits, a warm bath for a few minutes, wrap in blanket, cover well. Apoplectic fit, elderly person falls unconscious and paralysed; complete rest. Do not give stimulants. Epileptic fits—unconsciousness with convulsions; leave patient alone. He will recover soon. Then let him sleep.

Accidents.

Fractures.—Recognised by position and deformity of limb. If it is compound, *i.e.*, with an open wound, fill the wound with boracic acid powder, and send immediately for a doctor. If not compound, place in a position of rest. Take two pieces of light wooden splints, line with cotton wadding, place along the limb extending beyond the joints above and below, and apply bandages to maintain the splints in position.

Sprains.—A joint is strained. It will soon swell; apply a bandage before swelling ensues.

Hæmorrhage.—If a large wound, note if blood spurts. If so, apply a bandage tight around the limb above the wound; stick a piece of wood through the knotted end and twist to apply sufficient compression. If the wound is in the region of the temple, fold a coin in a piece of linen, place it over the wound, and bind a handkerchief around the head to maintain it. If, from a varicose vein, lay flat, and bind above and below the wound.

Burns and Scalds.—Remove the clothes carefully, if necessary cutting them away. Cover the surface well with flour or bread-soda. Put on a soft wrapping and apply a bandage. If a woman's clothes should be on fire, let her fall on the ground, and roll round and round. Heavy wrappings rapidly extinguish flames.

Sunstroke and Heatstroke.—Remove into the shade and strip off clothes. Pour cold water over head and neck and spine from a height of a few feet till patient begins to revive. Then, perfect rest.

Suffocation by Gas.—Let the rescuer take care of his own safety in entering the vitiated atmosphere. Bring the patient into the air, open the clothing, rouse with cold water, and carry on artificial respiration.

Drowning.—Free the mouth cavity, pull out the tongue, undo the clothing over the chest, endeavour to stimulate by smelling salts. Perform artificial respiration, if necessary, for two hours. When restored, apply artificial warmth to lower limbs and abdomen, give warm stimulants. Artificial respiration should include forcible slow compression of the lower half of the chest if a second helper is available, while the movement of expiration is being carried on by the person dealing with the arms.

Point out that the danger of drowning in sea bathing is most frequent in early morning bathing, when one has not first taken a cup of tea or coffee; in case of a weak heart; and from remaining too long in the water.

Poisoning.—Primary rule—find out as soon as possible what poison has been taken, and send for a doctor. Common poisons are strong acids, strong alkalis, carbolic acid; corrosive sublimate, opium, strychnine, prussic acid. Stains about the mouth suggest acids and alkalis. Treat them with olive oil, raw egg. If you know it to be an acid, give lime water. For the sublimate, white of egg. For opium, on no account let the patient fall asleep. Strychnine causes convulsions. Is the production of vomiting indicated in poisoning by acids and alkalis?

APPARATUS AND REAGENTS.

(In addition to the Physical and Chemical List.)

1. A Page gas regulator.
2. A hot-air bath, with water-jacket.
3. A piece of glass tubing bent into a U, 18 inches long.
4. India-rubber tubing, one yard.
5. Five dozen test tubes and racks.
6. Parchment tubing (for dialysis).
7. Dried gut of young animal (dialysis),
8. One dozen dissecting dishes, of metal, filled with paraffin wax.
9. Scalpels, forceps, scissors, strong pins.
10. Preparations of dextrose, lactose, maltose, de Witte's peptone, dried egg albumin, fibrin.
11. Preparations of pepsin, trypsin, and other digestive enzymes (Benger's fluids, or glycerine extracts).
12. Skeleton of human body.
13. Chart showing circulatory system in human body.
14. A clinical thermometer.
15. A few rolls of bandages.
16. Models of water closets.
17. Models of ventilating apparatus, such as Tobin's tube, Sheringham valve, louvre, cowl.
18. A microscope with low and high power objectives to a magnification of 360. (Average cost of microscope about £3.)

(8.)—GEOLOGY.

Introduction.

1. Seeing that Geology is concerned with the explanation of the existing features of the earth's surface, and thus with the past history of the district in which the study is undertaken, the most im-

portant observations must be made in the open air. But any excursion for the study of scenery, and for the collection of illustrative specimens, will provide material for investigation in the laboratory, and for comparison in types in the school-collection. The methods of such investigations will be for the most part familiar from previous chemical or physical work, and scarcely any fresh apparatus will be required. The organisation of the field-work will therefore be the first consideration; but an afternoon excursion of some three or four hours will often prove sufficient for the gathering of a large store of specimens and ideas. When the fundamental principles have once been grasped, every walk, or drive, or cycle-run across country will serve the pupil as a sort of unscholastic but helpful geological excursion; and the teacher may do well to lay stress on the geological features, not merely of the country near the school, but of the places to which the members of his class are likely to resort during their summer holidays.

2. The school should possess a geological map of the British Isles (Keith Johnston's, by Alex. Johnstone, is recommended), and copies of the local Ordnance Survey maps, geologically coloured. These are issued by the Geological Survey of Ireland (through Messrs. Hodges, Figgis & Co., Dublin), on the scale of one inch to one mile; price 3*s.* each. Multiple copies of parts of these can be made on any copying apparatus, for use by the class on field-excursions. On the ordinary gelatine machines, coloured inks can be used for shading the various formations in the copies made.

3. If the Ordnance Survey has also issued contoured sheets for the locality, these will be of great service in determining heights, which are only sparsely given on the geological sheets. For detailed work, one or more sheets may also be required on the scale of six inches to one mile.

4. Throughout the course, photographs or lantern-slides of Irish scenery, such as those issued by Welch, of Belfast, and Lawrence, of Dublin, and of larger scenic features in other countries, will be found of constant service. Each pupil should have a pocket-knife and a common triplet pocket-lens (costing about 3*s.*); any small hammer will serve for simple geological excursions, but the head should preferably have a square flat end for striking with, and opposite to it a chisel-edge, perpendicular to the shaft; the head should be well secured to the shaft by wooden wedges, which can be tightened by leaving the hammer for a time in water.

The Crust of the Earth.

1. The school should possess a collection of the following rock-forming minerals, in specimens about 7·5 by 5 cm., both crystallised and massive. The crystals may of course be shown by smaller specimens. Quartz, chalcedony and flint, magnetite, limonite, iron pyrites (pyrite and marcasite), rock-salt, calcite, aragonite, dolomite, gypsum, apatite, orthoclase-felspar, oligoclase-felspar, labradorite-felspar, augite, hornblende, olivine, muscovite-mica, biotite-mica, almandine-garnet, kaolin, one of the chlorites, serpentine. Also a few models of common natural crystals in wood, to illustrate what is meant by crystalline symmetry, thus :—

2. *Triclinic*; a triclinic felspar. *Monoclinic*; orthoclase; also an interpenetrant Carlsbad twin of orthoclase, as showing the common natural form; Augite; Hornblende; Gypsum. *Rhombic*; Olivine; Aragonite. *Tetragonal:* Zircon. *Hexagonal and Trigonal;* Beryl

(to show full hexagonal symmetry, which is rarely attained by minerals); Calcite (scalenohedron, rhombohedron, and rhombohedron combined with prism); Quartz (with trapezohedral planes on alternate angles, to show how this mineral falls short of complete hexagonal symmetry). *Cubic;* Magnetite (octahedron); Garnet (rhombic dodecahedron); Pyrite (cube, but also pentagonal dodecahedron, to show its falling short of complete cubic symmetry). A contact goniometer is desirable. (See below.) With these specimens and models as a comparative series in reserve, an excursion may be made to collect the materials of the crust. In most districts, few good *crystals* are obtainable; but *rocks* can be brought in for dissection in the laboratory, when it will be found that they are made up of a variety of mineral particles. These, such as the mineral constituents of granite or diorite, can be compared with the standard series; the hardness of grains of sand or the softness of clay-particles can be tested by pressing them between two plates of glass and observing any scratches produced; the specific gravity of, let us say, calcite from a vein can be found on a common chemical balance; and the behaviour of the same mineral in acid may be compared with the inactivity of quartz. Emphasise thus the distinctive characters of *mineral species*, using the pocket-knife and thumb-nail as tests in determining their relative hardness.

3. It will be found, then, that the earth's crust is composed of rocks, and that these are composed of a comparatively small number of mineral species. Point out the characters by which these minerals differ—hardness, specific gravity, behaviour with chemical reagents, crystalline form, cleavage. In dealing with crystalline form, the names of the various planes need not be given; but the grounds of reference of the forms to different systems should be stated. The constancy of angles in given mineral species must be relied on; from these observed angles the wooden models are constructed, in which each face of the same kind is made of the same size. In nature, however, this rarely happens; the symmetry of the whole form is spoiled by the unequal growth of the crystal in this or that direction; but the fundamental angular symmetry is not impaired, and remains to indicate the crystalline symmetry that prevails in the arrangement of the molecules which build up the crystal.

4. The constancy of certain angles may be tested with a goniometer on larger specimens in the collection, such as Quartz (angles between prism faces 120°; between adjacent rhombohedron faces 133° 44'); Garnet (in rhombic dodecahedron, between any two adjacent faces 120°); Calcite (over any of the three edges at top or bottom of a rhombohedron, broken out by cleavage, 105° 5'). The instrument known as the *contact goniometer* is easily constructed; but Mr. G. L. English, 812, Greenwich-street, New York, supplies Professor Penfield's types of the instrument in vulcanite and card, for class purposes, at about 2*s*. each.

5. The fact that many crystals are found "twinned" must be pointed out; also the dependence of cleavage on crystalline form. Cleavage is often of more service than the outer crystal form, which may be undeveloped in a specimen gathered from the rock.

6. In a district rich in *metallic ores*, a few of these may be dealt with, common blow-pipe tests being used in discrimination. Note the occurrence of such metallic minerals locally and in veins. Coal is not to be treated as a mineral, but as a rock of organic origin. (See page 153.)

7. Having obtained some idea of the materials of which the crust is made, the class proceeds to examine their arrangement in the crust. In the rocks collected, the crystalline constituents may be intergrown with one another, as in granite, or may be merely fragments held together by a cement, as in sandstone; or the rock may consist of one mineral massively developed, as in crystalline limestone; or of organic remains possessing a mineral constitution, as in fossiliferous limestone, such as that from the Carboniferous system. *Modes of origin of rocks*; some are stratified; some must be compared with the crystalline slags of furnaces, and have similarly consolidated from a molten state. How can their characters be explained? The class must observe the processes that are every day at work, making and unmaking rocks in the world around us.

The Slopes of the Hills; atmospheric agents that attack the Crust. Weathering of rocks.

1. In a road-side cutting or a quarry, note the passage from the solid bed-rock into loose broken rock, and then into *soil*. The surface soil may sometimes have been brought from a distance by the wash of rivers, &c.; but any rock-mass left to the action of the atmospheres will break up into its proper soil. Note how, in the case of a decomposing granite, all the constituents lie scattered about the surface, the felspar showing most evidence of decay; how slates and shales yield up a sticky clay; how limestones often yield only a thin sand or clay, which is merely their insoluble portion, the mass of the rock having been carried away in solution. Illustrate by dissolving any common limestone in acid, and examining the washed residue with a lens or microscope.

2. Describe the action of gases in the atmosphere on rocks; of rain and frost; of wind, laden with sand-grains like a sand-blast. Carving of pinnacles and gullies on exposed hill-sides. Heaps of *débris* (*taluses*) on mountain slopes. Show the nature and conical form of these in the field, and how farmers lay hold of them ultimately in mountain districts for cultivation.

3. *Landslips* assist the decay of a hillside; illustrate by slips in artificial banks or cuttings.

4. *Snowfields and glaciers*. Scratching of rocks under the moving ice. The action of glaciers is mainly one of transport; vast amount of material carried in or on the ice; appearance of this at the foot of the glacier, or as the whole ice melts finally away during a warmer period. Contribution of glaciers to the soils of Ireland; distribution of *boulder-clay* and *glacial gravels* as "drift" over the country. Origin of *eskers* and "green hills" in stream-tunnels under a great glacier. Traces of ancient glaciers in Ireland seen in the rounding and scratching of the rock-masses. Origin of *cirques* and mountain lakelets. Illustrate by photographs of Alpine and Arctic scenery, and, where possible, by visiting a drift-covered area and collecting scratched pebbles from it; clear the deposit away in part, so as to reach the underlying and smoothed rock-floor. Show pictures of rock-surfaces smoothed by ice-action in various parts of Ireland, such as Kerry or Connemara.

5. In conclusion, it will be seen that the precipitated moisture of the atmosphere, aided by the action of frost and wind, is responsible for most of the loose materials that lie upon the surface of the crust; and that these are derived from the decay of older solid masses. Examine soils and gravels by washing through sieves, and endeavour to trace the materials back to their parent rocks

6. *Apparatus required.*—Test-tubes or dishes, for dissolving limestones in hydrochloric acid. Simple microscope and glass-slips for examining residues and soils. Set of sieves, fitted together in series, with zinc floors pierced with circular holes; these are preferable to the ordinary wire-net sieves, as the diameter of the largest particles which pass through any sieve can be accurately known by the diameter of the holes; four sieves, about 12 cm. diameter, with holes respectively 5 mm., 2 mm., 1 mm., and 0·5 mm. in diameter, will suffice for ordinary operations.

The Action of Rivers.

1. In field excursions, note how streamlets arise on hillsides from the union of the trickling waters within the soil, or within mountain-bogs; how they are conspicuous after rain, and how they persist long after the rain has passed away. In many cases, the area drained by such a streamlet may be large enough to keep the water running between one rain-storm and another, without the help of subterranean springs. In other cases, the water that falls on one area emerges as a *spring* at some other place. If the source of the main river of the district cannot be visited, some tributary can generally be utilised. In limestone districts, note the disappearance of streams into solution-hollows, and their reappearance from underground channels. Lakes often supply a district with a large river, ready made, as it were, at its source.

2. Note how *débris* may accumulate on the floor where a tributary emerges on the main stream, or where a stream flows into a lake. Whence does this material come? Observe the clouding of the waters after heavy rain by *material in suspension.* Collect the water and allow it to settle; then filter, and evaporate. A second sediment is thus secured, which represents the *material carried invisibly in solution.* Now perform the operation quantitatively. Show how, by measuring the area of the cross-section of a small stream at some convenient point—*i.e.*, determining its width from bank to bank and the form of its bottom, and constructing a diagram to scale on paper ruled in squares, each representing one square decimetre—and by noting its rate of flow in decimetres per hour, the number of litres of water that pass the given point in an hour can be ascertained. From this calculate the number for twenty-four hours; show how, by observing the variation in flow and in the height of the water-level every day during a whole year, the flow of water for that year may be known; if the observations are continued for a series of years, the average flow per annum is found. If these observations are accompanied by determinations of the amounts of material carried in suspension and solution, the work of the river in *denuding* the land above the point selected can be estimated for an average year. All this material comes from the rocks of the river-valley. Unexpectedly large results are thus obtained.

3. Note also stones at bottom of stream, moved easily by it in times of flood. These are gradually rounded by friction on one another, and form *pebbles.* Action of the fine suspended material in polishing these stones and helping the cutting action of the stream, like emery-powder or sand in a stone-cutter's yard. More obvious and violent action in waterfalls. Pebbles stick in clefts of rocks, and drill out *pot-holes*; these unite, and whole blocks of rock are broken down. Origin of the deep pools under waterfalls.

4. *Relation of the stream to its valley.* Given the slope for it to start on, the stream slowly cuts out its own valley. *Ravines* imply

rapid action ; assistance is given by joints or planes of weakness in the rocks attacked. The rain smooths back the valley sides. Huge gorges arise where the river runs steeply and thus cuts rapidly, or where the rainfall is so small as to leave the vertical saw-action of the stream unmodified. The great cañons of America occur in practically rainless region ; those of the Alps are due to extremely rapid stream-action, which keeps ahead of the smoothing and widening action of the atmospheric waters.

5. Formation of *deltas* in lakes, and *alluvial cones* on hillsides, where much material is washed down and cannot be carried away. Choking of a valley ; *alluvial flats*. Note how the green meadows by the stream contrast often with the valley sides. Observe their pebbly or muddy materials. The stream wanders in loops and bends in the alluvium, often changing its course at some newly-deposited obstacle, and leaving old tracks behind it. Note cutting action on one bank, and alluvial deposit or pebble-shoal on the other. The stream is swinging towards the bank where the little excavated cliff appears.

6. Rock-masses formed by consolidation of alluvium. Sometimes the stream clears out its hollow again, leaving its old alluvium as a *river-terrace* on one side or on both. A succession of infillings and clearances produces a series of alluvial terraces at various heights. The causes of these changes are very various. A valley may be choked because a large amount of loose material lies up-stream, easily removed even by a river of moderate flow ; when this has been swept down into the lower part of the valley, choking the stream and producing an alluvial flat, hard rock alone remains up-stream, and the pure water, less highly charged and no longer over-loaded, cuts in its lower course into the material it previously laid down. Or a climatic change causes greater flow, and consequent sweeping out of the alluvium. Illustrate by the local variations in stream-deposits, as noted in successive visits. A talus-fan formed during the flooding of some side stream, often becomes cut away later, when the rush of loose material has ceased. The same facts are seen under hedge-rows, and in road-cuttings, after rain.

7. *Effects of earth-movements on the cutting power of streams ;* elevation of a country allows of deeper excavation. Depression below sea-level of course checks excavation in the portion of the valley flooded by the sea. Formation of long lakes by warping of valley-floors, and of *fjords* by submergence of valleys below the sea. *Islets* arise thus, such as the Skelligs or the Blasket Islands, and represent peaks that stood on the old valley-walls.

8. *Apparatus required.*—Evaporating dish, filter, &c., for river-water. Balance for the quantitative work. Measuring-tape for field-work ; objects, such as pieces of white wood, to float on stream in observing rate of flow. As the flow of a stream varies in its different levels, a weighted rod is preferably used, reaching nearly to the bottom of the stream and floating upright in the water ; this moves with the average velocity. (For illustrations, see *Encyclopædia Britannica*, 9th Edition, pp. 505-6.) Sieves for examination of alluvium, as in the previous section.

The Action of the Sea.

1. In studying what goes on upon a sea-shore, the same observational methods may be pursued as in the case of the stream. The sands may be sifted, and this or that constituent may be picked out. Note the great preponderance of

the more resisting materials, and how muds and fine limestone particles are floated away out to sea, leaving pebbles of quartzite (as in Co. Donegal), or flint (as in Co. Antrim), or jasper and quartz-rock and granite (as in Dublin and various counties of Ireland), to form beaches against the coast. The *sand* itself is a witness to the same natural processes of separation; the insoluble and resisting grains of crystalline silica remain behind in excess, and form our sandy stretches in the quiet bays. Compare these deposits with *Sandstone* and *Conglomerate*: Origin of these rocks in seas or lakes.

2. The winds seizes on the sands and piles them up into *dunes*. Note the constant struggle between the wind on the one hand, and the growth of bent-grass and other vegetation on the other. Movements of dunes, and their characteristic forms.

3. Note how *shells* accumulate at certain places. Ordinary marine sands of barren aspect yield numerous shell-fragments, and generally well preserved foraminiferal shells, when the sand-grains are sifted away. Show how the shells consist of calcium carbonate (using ordinary chemical tests), together with a certain amount of organic residue on solution in hydrochloric acid; this residue varies, with their degree of freshness. Discuss the relation of the shells to various organisms—foraminifera, sea urchins, bivalve and univalve molluscs, and crustacea. Brachiopod shells are rare on our coasts, but common elsewhere; these animals were abundant, however, in past times in Ireland, and even predominated in early days over the molluscs.

4. *Corals* and *calcareous seaweeds*.—Formation of reefs. Point out that the coral-polype is neither an "insect" nor "industrious," but that the reef results from the accumulation of coral-skeletons, infilled with calcareous seaweeds and foraminiferal deposits. Limits of coral reefs at the present day. Calcareous seaweeds of Ireland. Their use in the West for manuring land poor in lime.

5. Origin of most *limestones* in accumulations of the hard parts of marine organisms. Examine shelly limestones, such as the common Carboniferous Limestone of Ireland or the White Limestone of the North. A section under the microscope shows the whole mass to be of organic origin (here and there, recrystallisation of the aragonite or calcite of the original shells has destroyed the outlines of the organisms, and a less altered mass must in such cases be selected). Note how the *fossils*, the hard remains of dead organisms, often stand out on weathered surfaces of the rock, although the mass looks compact and inorganic in origin when freshly broken.

6. Origin of *stratification*. Thin but regular deposition of material in the oceanic regions remote from the actual coast. Limits of deposits formed of material washed down from the land. Only organic calcareous and siliceous deposits, and red clays derived from the decay of floating volcanic ash, are laid down in truly oceanic waters.

7. Examine various marine *sedimentary rocks*, so as to become familiar with their characters. Sandstone, clay, shale, limestone; foraminiferal and other deep-sea deposits, examined with the microscope.

8. The action of the sea as an accumulator and store-house of materials from the land has been dealt with first, since this is its most obvious aspect on an ordinary shore. But the sea is a powerful agent of denudation, and supplies a vast amount of detrital material to itself. Observe the results of storms. *Undercutting of cliffs.* Formation of *caves*. *Sea-stacks and pinnacles*. *Origin of bays*. Marine action is assisted where, by movement of the earth's crust,

the shore is sinking. *Raised beaches*, on the other hand, indicate elevation of the land; distinguish these from the accumulations thrown up above ordinary high-water by storms.

9. The foregoing matters can be brought out one by one in visits to the coast; where these are impracticable, samples of beach-deposits, pebble-banks, &c., should be obtained from some familiar Irish seaside resort, and the various components traced to their sources, organic or inorganic.

Plains and Deserts.

1. Relations of Plains and Deserts to adjacent hills. Study of maps of the various continents. *Growth of alluvial deposits in the lowlands.* Conversion of plains into deserts by climatic changes. *Salt-lakes* in arid regions; origin of rock-salt and gypsum beds. Ancient desert and salt-lake deposits near Carrickfergus. Sand-dunes in deserts.

2. Some plains are the floors of ancient seas, not yet folded by earth-movements or cut into by denudation.

3. Illustrate by specimens of Triassic sandstone and salt and gypsum from north-east Ireland. Show under the microscope the remarkable roundness of sand-grains from the Egyptian desert, or other region where the sand is in continual movement under influence of the wind.

Vegetable Deposits.

1. Action of vegetation in assisting the formation of soils. Note the wedging action of roots in road-cuttings or old hedgerows. Visit *peat-bog* and collect from the successive layers; note how the water prevents the scattering and free oxidation of the decaying vegetation; hence low-growing plants that love water have the best chance of forming permanent carbonaceous deposits. Observe, where the bog is cut away, the old floor on which it rests; often a layer of shelly limestone-mud is found, representing the floor of an old lake, on which the vegetation gradually encroached.

2. Plants that form peat or "turf"; swamp-vegetation in other countries; forest-deposits. Flotation of trees to the mouths of rivers; estuarine carbonaceous beds thus formed, interstratified with sands and clays.

3. *Coal* of various geological ages. Plant-remains best seen in the associated shales and sandstones. *Anthracite.* Coal-bearing areas in Ireland.

Diatomaceous deposits. "Kieselguhr." Illustrate by the kieselguhr of the Bann, Toome Bridge works, Co. Antrim (examine also with high power of the microscope).

Igneous Rocks.

1. *Volcanic action.* Tuff and ash. Lava-flows. Columnar structure. Crystals develop during cooling of the lava. Illustrate by specimens of crystalline groups often seen in glass from glass-works, or in slags from metallurgical furnaces. If polarised light is obtainable in connection with the microscope (an instrument with Nicol's prisms may probably be borrowed for this occasion), cross the Nicol's prisms, so as to produce darkness; then insert a plate of glass, to show that no change results when a non-crystalline body is introduced; then a plate of mica, to show that a crystalline substance may affect polarised light in such a way as to restore light between the crossed nicols. This enables the following experiment on *crystallisation from fusion* to be appreciated :—

Melt a little candle-grease on a glass microscope-slip, and cover with a cover-glass so as to make a thin film of grease. Place between crossed nicols, and observe that the molten mass behaves as a glass and produces no change. Watch the production of crystals as cooling proceeds; tiny rods of stearic acid separate out, ultimately forming a dense mesh; each crystal restores the light between the crossed nicols, and the first ones thus stand out brightly on a dark ground. The development of a crystalline mesh from a molten silicate magma in a lava-flow is thus well exemplified. *Minerals of the lava-flows*; *residual glass* occurs also in most cases.

2. Accumulation of materials, by explosion or gentler protrusion, to form *volcanic cones*. Extinction. *Geysers and mineral springs.* Slow cooling of igneous masses underground. Deep-seated igneous rocks, only revealed by denudation. *Dykes and larger intrusive masses.*

3. *Types of igneous rocks.* Granite; Diorite; Olivine-Gabbro. Rhyolite; Andesite; Dolerite and Basalt.

4. *Recognition of old volcanic areas.* Relics of lava-plateaux. The Giant's Causeway, and general phenomena of north-eastern Ireland.

Granitic rocks in Ireland. Granites of Donegal, Galway, the Leinster Chain, the Newry Axis, the Mourne Mountains. Carlingford Mountain; Slemish, and other masses of gabbro and dolerite.

5. *Illustrations.*—Excursions to any accessible igneous masses, such as the area between Croom and Limerick, the granite of Dublin and Wicklow, the Mourne area, and especially the counties of Antrim and Londonderry. Collect the rocks in place, if possible, and compare with a representative collection of igneous rocks. Note their distribution on the geological map of British Isles. Study them by comparing their texture or degree of crystallisation; the specific gravity of specimens of similar texture but different chemical composition; their mineral constitution, seen on breaking up the rock, sifting, and examining the finer particles, mounted in water, under the microscope. Explain the principles of the preparation of rock-sections for the microscope, and show some six or seven such sections. Polarised light need not be used, and only the degree of crystallisation and the general structure need be insisted on. Every microscopic section should be regarded as part of a rock-mass, and that mass as a definite portion of the earth's crust. Avoid elaborate terms in describing rock-structures, lest the pupil—who is not going to be a professional geologist—comes to regard geology as an exercise in classical terminology, rather than as a study dependent on the open country. The igneous rocks suggested for examination in microscopic section are:—Granite; Diorite; Olivine-Gabbro; glassy Rhyolite (Pitchstone or Obsidian); Andesite; Dolerite or Basalt.

Movements of the Earth's Crust.

1. Refer back to Raised Beaches ("Action of the Sea," par. 8.) *Upheaval and subsidence* at the present day. *Earthquakes* are probably incidents in general slow movements. Marine fossils, as already seen, show that land and sea have changed places in the past. *Uplifting and folding of strata* show that the solid crust has been raised above the sea, the sea at the same time withdrawing into new hollows provided for it by subsidence. *Strike and Dip.*

2. Measure dip in the field. Clinometers are easily made by mark-

ing a graduated arc on a card and suspending a little weight by a thread from the centre from which the arc has been drawn. Mark 0° at the apex of the arc, and 90° at the ends of the horizontal diameter. Show line of strike by a spirit-level and a rod, moving latter about on the dipping surface of a bed with the level on it until it lies horizontally. The direction of the rod then gives the strike. The true or greatest possible angle of dip is the angle made with the horizontal by a line perpendicular to the strike, and also lying in the surface of the bed. Set, then, the plane of the clinometer-arc perpendicular to the strike-line, and note true dip. Determine dip also as seen on a quarry-face or a natural section.

3. *Types of folding. Faults and overthrusts. Unconformity.* The gravel-capping on an Irish limestone-quarry is usually seen to be unconformable with the stratification of the underlying limestone.

4. *Structure of great mountain-chains.* Illustrate by folding a cloth, or layers of thick felt piled on one another. Show with a large crumpled cloth how anticlinals and synclinals die away at their ends on the earth's surface. Weathering of uptilted masses; *escarpments and dip-slopes.* Models may be made with layers of coloured clay or plasticine, and cut away with a knife to show the effects of denudation.

5. The geological maps of southern Ireland illustrate most of the features of mountain-folding. The pupils should learn at this stage to draw sketch-sections from the maps, so as to show the arrangement of the rocks below the surface.

Metamorphism.

1. Alteration of rocks under internal heat and pressure. *Baked rocks.* Altered limestones on the sides of dykes in Co. Antrim. Mica-schist as a product of *contact-metamorphism.* Compressed rocks; *slate.* Metamorphic *cleavage.*

2. *Foliation.* Crushing of ancient igneous rocks. Types of *schist* and *gneiss.* Development of minerals in these.

3. *Illustrations.*—Specimens of Irish metamorphic rocks. Excursion to igneous junctions, such as intrusion of granite in mica-schist at Killiney, Co. Dublin, if possible. Also to areas of ancient rocks, such as those in the highlands of Galway, Mayo, Donegal, or Londonderry.

The Geological Record.

1. Value of fossils in reading the past history of stratified rocks, and consequently of the district in which the school is situated. Succession of life-forms upon the globe. Observations of William Smith in 1798. *Systems* of strata. *Geological periods*

2. Difficulty of estimating the time represented by any geological period. *Succession of the systems,* from the Cambrian to the present day; faunas and floras characteristic of each. Steady progress towards more specialised types of life.

3. *Systems represented in Ireland.* Gaps in the record; comparison with England and with Scotland. Geological relation of the British Isles to the continent of Europe.

4. Illustrate by bringing together fossils from different horizons. In the north of Ireland this can conveniently be done by actual field-collection in a limited area. Elsewhere, the local collection may be formed and may be compared and contrasted with other representative series. Drawings of fossil reptiles and mammals should be shown, as these types are essential to a realisation of the fauna, although

their remains are comparatively rare. The *species* of fossils found locally may be discussed, and the value of species in marking out *zones* may be pointed out; but otherwise only the broad aspect of a fauna need be dwelt on, and even generic characters should be sparingly introduced. The young worker who has acquired the names of fossil species very rarely knows the grounds on which any one species has been established; and experienced geologists are naturally and properly accustomed to check the species in their collections by comparison with the original descriptions. This cannot well be done away from public libraries; and hence the learning of lists of fossil species during school-work is merely an encouragement to self-deception. Every specimen that is handled should be made of some service in conjuring up a picture of the past—in making the pupil realise the strange vicissitudes that any common plot of Irish land has undergone. At the same time a lasting impression will be gained of the long chains of life-forms that lead up to the familiar fauna and flora of to-day.

(9.)—DRAWING.

SUGGESTIONS FOR THE TEACHING OF DRAWING.

Elementary Freehand.

The drawings should be made on plain paper, either in books or on separate sheets, of about quarter imperial size, *i.e.*, 15 inches by 11 inches; thin and soft paper should be avoided. When separate sheet are used, it is advisable to keep the drawings in portfolios or large paper envelopes, which can be made by the pupils.

The course should be carefully graduated according to the ability of the class, the work of one lesson indicating to a considerable extent what is best for the next. Drawings should always be made larger or smaller than the originals; never of the same size.

The collective method of teaching will be found best when the classes are large and the capacity of the pupils varies considerably. If the examples are well selected, it will be found that all the pupils have to grapple with the same difficulties to a greater or less degree. To draw the simplest example well, will require careful attention from even the best pupils; the slower pupils should be able to get through the "setting-out," and also to complete a portion of the drawing in detail.

A large diagram should be placed in front of the class, so that each pupil may have a front view. If the room is wide, two or three examples may be required. Before drawing is begun, the example should be carefully studied by the pupils with the help of the teacher, who should point out the importance of noting the structural lines and proportions at the beginning. The teacher should also draw attention to the principles of ornament illustrated, and the use to which the piece of ornament might be put in design. He should then make a sketch on the blackboard, showing the leading lines. (The pupils should make their drawings from the original; the teacher's drawing having been removed.) The structural and leading lines should be sketched in light continuous lines, and not in short unmeaning strokes or dots.

If the example is symmetrical, the centre line should be drawn first; next the leading line on the left-hand side, then the corresponding line on the right; and so on, from the largest parts to the smallest detail. Should the example be unsymmetrical, the structural lines and general proportions should be set out first, and the details should follow. Pupils should be encouraged to hold their drawings at arm's length occasionally, so as to test their estimate of the proportions, the direction of the leading lines, &c.; they should also test the proportions by means of the upheld pencil or ruler.

If the leading lines and proportions are put in with faint but discernible lines and the drawing is planned from the largest masses to the smallest details, as described above, it will not be necessary to erase the first sketch; the finished lines can be put in directly, and there will be no necessity for the so-called "lining in."

The rubber should be used as little as possible; and it would be well to have an occasional lesson in which its use is prohibited.

Though it is often necessary for the teacher to work on pupils' drawings, both to correct errors and to show how the pencil should be used, it is usually best to illustrate general errors on the blackboard and only individual errors by slight sketches on the margin of the pupil's drawing. Attention should be called not only to the difference between the pupil's work and the original, but also to the principles violated.

Some of the best pupils, who, as a rule, finish their drawings before the end of the lesson, might, with advantage, be given an exercise in simple design, or set to line their drawings with the brush, or to tint them with water-colour or crayon. If crayon is used, the colour should be put in with the point in parallel lines, the direction of which might be varied in the spaces at the opposite sides of a symmetrical example. Such lines in any one space should, however, be parallel throughout that space; the colour should not be put in with a rag or stump. The result should be clear and precise. Exercises in drawing with chalk on the blackboard to a large scale, might with advantage be carried on concurrently with Freehand, Model and Object Drawing, and Design.

Simple Exercises in Design.

To avoid misunderstanding, it is explained that, while the term "Design" ordinarily connotes invention, it is employed here in a much more restricted sense. The faculty of invention is a natural, and not an acquired, power; but, by affording scope, under proper direction, latent capacity for invention may be developed. It is therefore clearly not intended to teach invention, nor even to study how designs may be executed in crafts: it is only proposed to provide exercises in simple composition and arrangement—pattern-drawing, as it is often called—and to show by the application of the rules of composition (repetition, alternation, &c.), how ornamental forms can be constructed by means of simple elements. The main object of the lessons is to capture the pupil's interest, to make him feel that he is throwing his personality into the exercise, and that the difference between his result and that of his neighbour is one due mainly to his own individuality. Individuality may be shown even in drawing a straight or a curved line; but a pupil's "joy in achievement" grows as, aided only by the rules of composition, he creates his own effect. The teacher in this way enlists the most valuable assistance in the study of Drawing—the pupil's co-operation.

Squared paper, in which the squares are not less than 1-inch side, may be used at the beginning.

The teacher might draw a design for a border (composed of a few horizontal lines with squares between) with coloured chalks on the blackboard; this should be copied by the pupils with water-colour or coloured crayon; the colouring should be done with the point; rulers and set-squares may be used. The pupils should then be set to make a new design, using the same elements and following the same principles.

Another form of exercise is to be set at Freehand pattern to be copied, and to instruct the pupils to make a variation on it; or, if the pattern forms a suitable unit for repetition, to make a design for a border or other repeating pattern based on it.

Another suitable kind of exercise is to form simple geometrical shapes by means of compass and ruler, and to draw Freehand forms within them, filling in with flat washes of colour.

Simple designs may also be made by means of brush impressions and strokes on the squared paper.

Natural objects are the best guides to good colour; such objects as stones, shells, feathers, birds, plants, trees, flowers, leaves,. &c., offer endless suggestions. The exercises in composition, after being carried to a certain stage in the class, form convenient subjects for home-work. The teacher will criticise these exercises with sympathy, and will also exhibit good designs for comparison.

Object Drawing from the Flat.

Object Drawing from the flat as a variation of Freehand is to be confined to the first year of the Preliminary Course. The school should be provided with a good set of examples of common objects for the guidance of the teacher, and the teacher should always exhibit the real object alongside of the Drawing, and should point out its peculiarities, contrasting it with similar objects. Object Drawings of this character should be made from the teacher's drawings on the blackboard, or on large sheets of paper with charcoal. The use of guiding lines should be strictly limited, and as soon as possible avoided, since they tend to throw the pupil's mind off the form under consideration.

The examples used in Freehand and Object Drawing should be varied as much as possible. Freehand examples should be copies (or photos) of good ornament, and the common objects selected should be of good artistic form.

Memory Drawing.

Memory Drawing is, perhaps, the most important branch of the course in Drawing; its value can hardly be over-estimated.

In drawing from the flat, or from an object, the necessary facts may be noted singly and transferred to paper, each as it is correctly appreciated. In drawing from memory all the necessary facts must first be gathered in by the eye. It will thus be seen that Memory Drawing necessitates keen and intelligent observation on the part of the pupils in order to gain correct impressions. It excites their interest, and leads to a spontaneous and freer style of Drawing than mere copying does; the lines drawn are usually better than those of the Drawing lessons from examples or models; while the pupils' minds are intent on remembering the form, they do not think too much of the lines. It is one of the best means of measuring the technical ability of the pupils, and of testing how much of a lesson they have learned.

Pupils in this way gradually gain the power of rapidly seizing and retaining the essential features of pieces of ornament, objects, &c., thereby laying up a store of ideas, which is of the highest importance in design. The best and most original designs are made by persons who, among other qualifications, know most about the history of Ornamental Art, and have studied the best examples.

It is advisable to have special books or paper for Memory Drawing.

In the early stages the last ten minutes of a lesson may be devoted to drawing from memory the example just completed from a pattern.

The next step might be to draw from memory the example studied at the provious lesson. Further, an example might be exhibited for a short time, and the pupils should be required to give expression to the idea left on their minds.

The examples used should be those previously studied in Freehand, Object Drawing, and Design; pupils might also be instructed to do some Memory Drawing as a home exercise; they should also be encouraged to draw familiar objects, such as pieces of Science apparatus, domestic objects, farm utensils, portions of buildings, &c., &c.

In drawing complex objects from memory, the greatest attention should be given to the structural lines and proportions.

Freehand from the Cast.

The same general principles should govern this subject as those set forth for Freehand from the flat. The models should be good casts of ornament in low relief.

Pupils who have mastered the proper method of setting out, and can make a drawing, which is good in construction and proportion, might be allowed to finish their work with a pen or brush outline.

Design based on Natural Forms.

The geometrical basis of a design should always be carefully drawn with instruments. In using natural elements, the special character of the forms used should, though treated ornamentally, be maintained as far as possible: for instance, stiffly growing plants should not be forced into lines suitable to trailing or creeping plants. Some limitations should be laid down for each exercise, *e.g.*, in outline; in monochrome of one, two, or three tones; in two or more colours, &c. Exercises in repeating patterns should be practised, *e.g.*, running borders and all-over patterns, and also the filling in of such geometrical spaces as the square, rectangle, triangle, circle, &c.

Model and Object Drawing from the Round.

In drawing from common objects and from geometrical models, pupils should be seated so as to face the models directly, and at sufficient distance to see the whole model or group of models. In schools which are provided with single desks this can easily be done by placing the desks in a circle round the models. Where the desks are long and paralled to each other, the pupils should be provided with drawing boards, and should sit so that the top edge of the board is at right angles to "the line of sight." The first lesson might with advantage be devoted to demonstrating the use of the pencil in making comparative measurements, and to securing the direction of lines; it should be made clear that the pencil must always be held at the full length of the arm, and in a plane at right angles to "the line of sight." To obtain the pencil in this position it would be well to require the pupils to hold it between the tips of the first fingers of each hand. At first only large models or objects should be used. A large circular board freely suspended in a horizonal position, so that it can be placed above or below the level of the eye, will be found most suitable, as it can be arranged in such a manner that all the class have so nearly the same view that general instruction is possible. Such models as a door first closed, then open; maps; a blackboard first vertical, then laid horizontally; the cube, rectangular prism, &c., should follow. The geometrical models are recommended because their severely simple form enables teachers to demonstrate principles from them without confusion; it should be pointed out how the principle learned from the study of these type forms may be applied to the drawing of common objects of similar form; and teachers might show how easily a well drawn cube may be made into a well drawn chair or stool; in fact, what slight changes or additions will make the drawings of geometrical models good drawings of familiar objects. In correcting Model or Object Drawings the teacher should be careful to place his eye in the same position as was occupied by that of the pupil when the drawing was made.

Memory Drawing in this subject should be practised.

Shading.

The paper used should not be too smooth. "Whatman's Not," or some similar kind, will be found most suitable.

The point or stump may be used.

At first a few exercises might be worked from the flat; the teacher might draw three squares and fill in each with a flat tone; the pupils should then try and match these tones. When they can do this fairly well, they might be instructed to copy a square in which the tone is graduated from high light in the top left hand corner to dark shadow in the lower right hand corner. After a few exercises of this kind models should be used; such a model as a white cube, hexagonal prism, or a truncated square pyramid on a square slab, would be best to begin with. The model should be placed in a strong light from one source, and studied as a whole before commencing to shade. The same general principle should be followed in this as in all Art work, *i.e.*, first obtain the general effect in the simplest manner possible. This is usually done by working from the largest masses to the smaller details, and from the broad divisions of light and shade to the half-tones.

The school should be provided with casts of fruit, flowers, architectural details, &c., in high relief and the round.

Teachers should point out that the same general methods should be employed in shading casts of apples, oranges, &c., as are employed in shading a sphere.

Modelling.

Modelling should be taught concurrently with practice in Freehand and Model Drawing.

Clay is the best material to use, but where little modelling is done plasticine will be found a good substitute.

Ordinary roofing slates or boards should be used for working on.

The first lessons might be devoted to demonstrating the nature of the material and to the modelling of simple mouldings; a cavetto might be taken, and the teacher should draw an elevation and section on the blackboard, and model it on a large scale before the class. The work should be built up bit by bit by means of the thumb and fingers, tools and carving being used as little as possible. The next step would be the enrichment of these mouldings either by means of incised lines or by the application of simple geometrical forms in low relief.

The modelling of simpe rosettes should follow. From this stage onward the work should be done on clay or plasticine slabs spread over the slate or board, casts of human features and of good ornament in different styles being used as examples.

Design should be practised by making variations on the examples copied, and by the application of natural forms.

Geometrical and Mechanical Drawing.

The most important points to be considered in this work are—correct knowledge of geometrical definitions, accurate measurement, the proper use of instruments, and clearness and sharpness of line. In the first stages drawing-books may be used; the correct use of rulers, set squares, simple scales, and compasses should be taught.

When the "T" square is used (its use should be taught as soon as possible) separate sheets of paper will be found more convenient than books, and drawing boards will be necessary. Pupils should be provided with a suitable hard pencil, and with compasses furnished with a hard pencil point. These should be properly sharpened, as on this to a great extent the neatness and accuracy of the work depends. The ruling of the page into several rectangular compartments also adds to the neatness of the work.

In teaching Geometrical Drawing, even in the earliest stages, its practical application to the setting out of Ornamental patterns and to the drawing of machine and building details should be pointed out. For instance, when the pupils know how to construct a scale of, say, one inch to one foot, and to draw a rectangle by means of that scale, the teacher should ask the pupils to measure the door or window opening of the school, and then make a drawing of it, using the scale which they have constructed. Next, the door with its panels, or the window, with its panes of glass, might be drawn; then pieces of the school furniture, and so on, perhaps, to the plan elevation and section of the school building. Such models as the hinges of doors and gates, bolts, &c., might also be drawn to scale, and in schools which possess models, or real pieces of machinery, these should be drawn to scale.

A hinged blackboard will be found most useful in teaching Solid Geometry, and pupils should be encouraged to make paper or card-board models to help them to understand the problems under consideration.

Teachers should always be careful to choose simple models to begin with, and to have their course of instruction carefully graded.

THIRD YEAR SYLLABUS.

DIVISION I.

Freehand in outline from Casts in low relief, or Modelling from the Cast; or both.

Simple Design, drawn or modelled, based on natural forms. Model Drawing from geometrical models and familiar objects—not more than two models (or objects) and the board in one group.

Memory Drawing, or Modelling from Memory.

NOTE.—Studies in Outline of Plant Form from Nature (or Modelling Plant Form from Nature) may be made in conjunction with Outline or Modelling from the Cast.

DIVISION II.

Geometrical Drawing, based on the constructions involved in the following:—

(1.) Constructions required in geometrical pattern-drawing, simple tracery, and mouldings.

(2.) Construction of regular polygons—general and special methods; inscribed and circumscribed circles; simple cases of rectilinear figures described in or about other rectilinear figures.

(3.) Circles—passing through three points—touching three lines; tangent lines and circles to one or two circles.

(4.) Ellipse: method of construction; drawing its tangents and normals.

(5.) The construction and measurement of angles by the use of protractors. The construction of triangles from given data.

(6.) Construction of irregular polygons from given data. Similar figures—equal, enlarged, or reduced.

(7.) Plain and diagonal scales and scale of chords; proportional division of lines, including the mean, third and fourth proportionals; reduction of polygons to triangles of equal area; construction of parallelogram or square equal to a given triangle or other rectilinear figure.

Solid Geometry: plans and elevation of cube, prism, pyramid, cone, and sphere in simple positions; and sections by vertical, horizontal, and inclined planes.

FOURTH YEAR SYLLABUS.

DIVISION I. (BOYS AND GIRLS.)

Model and Object Drawing, more advanced than that required for third year.

Drawing in Light and Shade from the Cast and from Common Objects, and Design; or Modelling from the Cast, and Modelling Design.

Memory Drawing, or Modelling from Memory.

NOTE.—Studies in Outline of Plant Form from Nature, or Modelling of Plant Form from Nature, more advanced than those of the third year, may be made in conjunction with Model and Object Drawing or Modelling.

DIVISION II. (GIRLS ONLY.)

Geometrical Drawing.—The application of third year work to common objects, and the setting out of ornamental patterns, &c.

DIVISION II. (BOYS ONLY.)

Geometrical Drawing.

The application of third year work to common objects, simple machine or building details, and the setting out of ornamental patterns, &c.

Drawing from measurements and sketches made by the pupils themselves.

Solid Geometry.

1. The Principles of Projection; definitions of terms in general use, such as ground line, or xy line, projector, plan, elevation, section, trace, planes of projection, &c.

2. Representation of a point in space, by its plan and elevation, in all possible positions with respect to the planes of projection.

3. Representation of vertical and horizontal lines.

4. Given the plans and elevation of a line, to determine:—
   - (*a.*) The traces of the line.
   - (*b.*) Its true length, and its inclination to each plane of projection. Conversely determine the projections of line when its inclination to each of the planes of projection is given.
   - (*c.*) A new elevation of the line on any assigned ground line.

5. Determination of the real angle between two lines which meet.

6. Representation of parallel lines.

7. Simple problems relating to lines.

8. Representation of a plane by its traces:—
   - (*a.*) At right angles to one plane of projection, and inclined at any angle to the other.
   - (*b.*) Perpendicular to both planes of projection.
   - (*c.*) Parallel to the ground line.
   - (*d.*) In any position with respect to the planes of projection.

9. Given the traces of a plane, to determine its inclination to each of the planes of projection.

10. Determination of the intersection of two given planes.

11. Determination of the intersection of three given planes.

12. Dermination of the real angle between the traces of a given plane.

13. Determination of the angle between two given planes.

14. Determination of the intersection of a line and a plane.

15. Determination of the projections and real length of a perpendicular let fall from a given point on a given plane.

16. Determination of horizontal lines, and of lines of given inclination, in given planes.

17. Simple problems relating to planes. Plans, elevations, and sections, of the solids, enumerated for third year, in more difficult positions.

LIST OF SUITABLE EXAMPLES, BOOKS, &c.

These lists of examples, books, models, &c., have been drawn up to help managers of schools in selecting equipment for their Drawing Classes. *They are solely for guidance and are not listsof requisites.*

FREEHAND DRAWING.

(*a.*) The "Design" Freehand Drawing Sheets, Published by Davis & Moughton, Ltd., Birmingham. Price, 12*s.* per set.
(*b.*) Bacon's Soft Grey Line Drawing Charts, coloured; Parts I. to VI. Published by Bacon & Co., Ltd., 127, Strand, London. Price, 7*s.* 6*d.* per set.
(*c.*) M'Dougall's Constructive Drawing Charts. Published by M'Dougall's Educational Co., 24, Warwick-lane, London, E.C. Price, 8*s.* per set.

Schools should possess at least one complete set of (*a*), (*b*), or (*c*).

OBJECT DRAWING AND BRUSH DRAWING.

(1.) Bacon's Common Object Series, 4 sets, 24 cards each; 1*s.* 6*d.* per set. Published by Bacon & Co., Ltd., 127, Strand, London.
(2.) Free-Arm and Blackboard Drawing, First, Second, and Third Series, price 2*s.* 6*d.* each. Published by M'Dougall's Educational Company, Ltd., 1 and 2, St. James's-square, Edinburgh.
(3.) Brush Drawing and Design, First, Second, and Third Series, price 5*s.* each. Published by M'Dougall's Educational Company, Ltd., 1 and 2, St. James's-square, Edinburgh.

DESIGN.

A selection from the following will be found useful:—

(1.) Geometrical Design, by J. Petty. Price, 2*s.* Published by E. J. Arnold & Son, Ltd., Leeds.
(2.) The New Art Geometry, by Steeley and Trotman. Price, 2*s.* Published by Bacon & Co., Ltd., 127, Strand, London, W.C.
(3.) Elementary Drawing and Design, by E. R. Taylor. Published by Macmillan & Co. Price, 2*s.* 6*d.*
(4.) The A.B.C. of Drawing, by F. G. Jackson. Published by Chapman & Hall. Two parts. Price, 2*s.* 6*d.* each.
(5.) The A.B.C. of Design, by F. G. Jackson. Published by Chapman & Hall. Two parts. Price, 2*s.* 6*d.* each.
(6.) Dawson's Elementary Design. Published by Chapman & Hall. Price, 3*s.*

BOOKS.

Many good books on Design, Art Teaching, Principles of Ornament, &c., are published by the following firms, viz.:— Messrs. Chapman & Hall, 11 Henrietta-street, Covent Garden, London, W.C.; Messrs. B. T. Batsford & Co., 94, High Holborn, London, W.C.; Messrs Blackie & Son, Ltd., 50, Old Bailey, London, E.C.; from which firms catalogues can be obtained. Most of the books and models mentioned below can be had from the usual educational supply firms in Dublin, Belfast, and Cork.

Among the most useful books for Secondary Schools are the following:—

Elementary Art Teaching, by E. R. Taylor.
How to Teach Drawing in Elementary Schools, by T. R. Ablett.
Lessons on Decorative Design, by F. G. Jackson.
The Rudiments of Design, based on Plant Form, by H. T. Wyse.
Japanese Encyclopædia of Design, Book II.
Alphabets, Old and New, by L. F. Day.
Moody's Lectures and Lessons on Art.
Glaisher's Outline's of Historic Styles of Ornament.
Progressive Design for Art Students by James Ward.
Plant Drawing and Design, by Lilley and Midgley.
Modelling—A guide for Teachers and Students, by Prof. Lanteri. Two volumes.

MODELS.

For the third and fourth years' Drawing courses a complete set of Geometrical Models, which can be had from Chapman & Hall, or educational supply firms in Dublin, Belfast, or Cork, will be required, also a good selection of Casts.

The set of Models should include the following:—

Cone; base, 10 inches diameter; axis, or altitude, 15 inches.

Ring; outside diameter, 12 inches; section, 1½ inches by 1½ inches.

Square prism; edge of base, 7½ inches; length or altitude, 15 inches.

White unglazed long-necked bottle; height, 12¾ inches; greatest width, 6½ inches.

Cylinder; base, 8 inches diameter; length or altitude, 12 inches.

Large Solid Cube; edge, 10 inches.

Large unglazed terra-cotta Vase; height, 9½ inches; greatest width, 8¼ inches.

Hexagonal Prism; edge of base, 4½ inches; length or altitude, 15 inches.

Triangular Prism; edge of base, 8 inches; length or altitude, 15 inches.

Square Pyramid; edge of base, 10 inches; altitude, 14 inches.

Sphere; 9½ inches diameter.

Skeleton Cube; outside edge, 12 inches; section of frame-work, 1¾ inches by 1¾ inches.

Red glazed Vase; height, 10¼ inches; greatest width, 7 inches.

Small solid Cube; edge, 6 inches.

Wooden imitations of the bottle and vases should be scrupulously avoided.

CASTS.

Suitable Casts can be had from the following firms, viz.:—Brucciani & Co., 254, Goswell-road, London, E.C.; Chapman & Hall, Ltd., 11, Henrietta-street, Covent Garden, London, W.C. (The latter firm publishes a catalogue with about 500 photographic illustrations of casts, including casts of details from nature, by L. Guintini. Price, 2*s.* net. A copy of this catalogue will be forwarded on application free to educational authorities.)

Casts of details from Nature, *i.e.*, hands, feet, &c., can be had from Lorenzo Guintini, 47, Rotherwood-road, Putney, London, S.W.

The following list of Casts will serve as a guide to the kind which might be used for the different classes of work set out in the Department's Programme.

CASTS FOR OUTLINE DRAWING.

From Brucciani & Co. (The numbers are those in Catalogue.)

				s.	*d.*
No.	6	Panel 2	Tomb of St. Antonio, Padua,	3	0
,,	8	,, 4	,, ,, ,,	3	0
,,	10	,, 6	,, ,, ,,	3	0
,,	13	,, 9	,, ,, ,,	3	0
,,	14	,, 10	,, ,, ,,	3	0
,,	15	,, 11	,, ,, ,,	3	0
,,	16	,, 12	,, ,, ,,	3	0
,,	17	,, 13	,, ,, ,,	3	0
,,	209	Monumental Tablet (1851, 437),		7	6
,,	2,480	Four Caps, Louis XII. Pilasters, 2*s.* each—the set,		8	0
,,	2,315	Ten Elementary Studies of Ornament (separate, 2*s.* 6*d* each)—the set,		20	0

From Messrs. Chapman & Hall. (Numbers given are those in the Catalogue.) 46, 47, 54, 70, 71, 72, 73, and others of similar relief.

CASTS FOR SHADING AND MODELLING.

From Brucciani & Co.

		s.	*d.*
485.	Moulding Boss, from St. Stephen's, Westminster,	4	0
1,540.	Centre Rosette, from Trajan Scroll,	7	6
1,639. A.	Portion of Spandril, from Stonechurch, Kent,	6	0
1,639. B.	,, ,, ,, ,, ,,	6	0
2,670.	Egg and Tongue Moulding,	4	0
2,754.	Piece of Gothic Foliage,	5	0

	s.	d.
344. Rosette, from the Capitol,	4	0
345. ,, ,, ,,	4	0
2,248. Left Eye of David, by Michael Angelo,	2	6
2,249. Right Eye ,, ,, ,,	2	6
2,249. A. Left Ear ,, ,,	2	6
2,249. B. Right Ear ,, ,,	2	6
2,250. Mouth ,, ,, ,,	2	6
2,250. A. Nose ,, ,, ,,	2	6
2,891. St. John, by Donatello,	5	0

From Chapman & Hall.

No. 56, 3*s.*; 75, 2*s.* 6*d.*; 78, 1*s.*; 389 to 402, 4*s.* 6*d.* each; 465, 2*s.*; 463, 2*s.*

From M. Lucchesi, 36, Charles-street, Hatton Garden, London, W.C.

Set of Twelve Animals' Heads, ... £1 5 0

The following will be found valuable by Schools taking Modelling:—

From Chapman & Hall.

	s.	d.
Cast of a Bust, First and Second Stages,	8	0 each, net.
,, ,, complete	6	6 net.
,, Foot, First and Second Stages,	4	6 each, net.
,, ,, complete, ...	4	6 net.

(10 & 11.)—DOMESTIC ECONOMY.

INTRODUCTION.

Instruction in Domestic Economy has come to be regarded as an essential feature of a girl's education. The formation of public opinion in this respect and its growth to the conclusion stated has been due to an increasing liberality in educational views; to the perceptible increasing complexity of the operations involved in the management of a home, with its ever widening circle of relationship to the individual, to society, and to the national standard of health and comfort; to a desire, itself the outcome of a rising standard of general education, to become skilled in the domestic arts, and to obtain some insight into the principles and processes involved; and to the deepening conviction that the application to the activities of a home of the facts of her own experience, or of those of her family, is insufficient to enable a woman to cope successfully with the many-sided demands made on one entrusted with the care and supervision of the young, with the spending of a family income, and with duties involving a knowledge of accounts, rates, taxes, insurance, principles of sanitation, and management of servants.

The subject is eminently a practical one. So true is this that many still contend that the home is the only possible training school. No doubt the home must be the central fact, and home influence and experience dominating factors in the instruction; but it must be remembered that the subject-matter of Domestic Economy forms most valuable material for the general education of girls, and that to treat it with sufficient importance requires opportunity and organization, such as the home cannot provide. Further, it should not be overlooked that intelligent interest, a sense of the dignity of domestic work, and a conviction that the home provides full play for intellectual capacity—necessary conditions of successful management—can be developed through a study of the collective wisdom of the best house managers and a critical examination of their methods, recipes, and practice in the light of the teachings of modern science; and that such treatment of the subject is possible in the majority of cases only through co-operation and centralisation of efforts, *i.e.*, in the school.

It is possible that the majority of Secondary School girls may never be called on habitually to perform the ordinary duties of a household, nevertheless they cannot hope to become good managers without knowing how household work is done, and without being capable, if necessary, of doing it. Moreover, as has already been indicated, ability, however great, to perform the daily routine duties of a household does not form the complete equipment of a good manager. Such an one should understand the function, cost, and economic preparation of food; the function, cost, and making and repairing of clothes; the keeping of accounts; the percentage of income that should be allocated to each head of expense, including provision for the future; the selection, lighting, warming, ventilation, and sanitation of houses; the laws of health; sickness and nursing—in a word, she must understand how to spend a family income to the best advantage, and she must be capable of applying this knowledge to the special circumstances of the household for which she is responsible.

With such ends in view, the practice-lessons suggested in the following syllabuses should not be of a mechanical character, *i.e.* repetitions of exercises until the pupils must needs do them, as taught. The instruction should aim rather at bringing home to the minds of the pupils, by critical discussion of the facts of experience and by experiment, a good understanding of underlying principles, *and at providing sufficient practice to illustrate these principles fully.*

The subject, as treated in the Special Course, should be introduced into the school curriculum during the last two or three years of school life, but the Auxiliary Course may be taken up much earlier. The teaching should be based on the previous, and possibly concurrent, studies in Experimental Science, utilising the facts and applying the *methods* of those lessons, and displacing the vague quantities, approximate measurements, and empirical knowledge of the average housekeeper by the exact quantities and measurements, and by the reasoned experience to which the pupil has now become accustomed. Further, the closest relationship should exist between the school work in Domestic Economy and in such other subjects as Arithmetic, Drawing, and English.

It will thus be seen that the subject, as proposed to be treated, is a wide one, one on which much of the previous teaching may be brought to bear, and one which may be largely used to show (which is by no means too clear) that school studies do have some relation to the outer world, and do form some preparation for right living.

Hygiene and Economy.

As a rule the Hygiene and Economy may be taught by lecture and demonstration in the class-room. The practice lessons, and experiments, must however be worked through *by the* *pupils themselves* in the kitchen, the sewing-room, or the laboratory. At practice, pupils should work in pairs: not in groups of three or four.

The concurrent study of Physiology would be a great help to the teaching of Domestic Economy on the lines suggested in this syllabus; and in those schools which do not take up the separate study of Physiology and Hygiene, the simpler facts of those Sciences will require some attention in the first year of the Special Course in Domestic Economy.

That part of the syllabus which deals with the composition of foods and with their nutritive values cannot be too clearly dealt with, for the domestic and social evils arising mainly from insufficient nourishment are too common to call for comment. The dangers of injudicious choice of foods should also be clearly brought out.

The greatest stress, however, is laid on those parts of the syllabus which deal with household accounts and expenditure; and the normal grant will be recommended only for those schools in which that part of the work is thoroughly well done.

For the lessons that come under the head of Practice in cookery and cleaning, a list is given showing how the different operations may be combined with demonstration cookery and cleaning.

Practice.

It must not be overlooked, however, that demonstration should occupy but a subordinate place in these practice lessons; and further, that it should be confined to what the pupils cannot be reasonably expected to think out for themselves, and that so far from superseding, should rather aim at developing the initiative of the pupils. At a practice lesson *every* pupil should have enough work to occupy her for the full period of the lesson. The demonstration of a new process is not always to be given at the beginning of a lesson, but should come in at the appropriate time. It is also well to vary the method, and, occasionally, instead of giving a general demonstration, to let the pupils try a certain process for themselves, and to show those that fail to what failure is due. Demonstration should aim at guiding the class rather than at leading it.

It is in these practice lessons that not only the art of cooking and cleaning may be mastered, but also (under a good teacher) that the true spirit of economy—thrift and management—can be developed.

The pupils should have large aprons (studio pattern); the hair should be kept tidy; and nothing slovenly should be allowed.

Not alone should the price of each dish be given, but the *menu* should, if possible, be arranged for a small number of persons; and, if the girls dine at the school, the art of serving food can be easily taught.

Simplicity of dishes, smallness of price, and a certain cost per head should be always aimed at.

Under a skilful teacher, a number of indefinable good qualities can be cultivated: the kitchen should be made a ground for developing a girl's neatness and taste, and not converted into a place where she looses these qualities.

NOTE.—*Managers of Girls' Schools are advised to take up the study of Domestic Economy along with that of Physiology and Hygiene. The teacher should read over the separate syllabus of that subject.*

SPECIAL COURSE.—THIRD YEAR SYLLABUS.

HYGIENE.

1. *Description of human body*, aided by charts; division based on simple experience; bones, muscles, nerves, blood, skin. Lessons purely introductory, and confined to physical differences.

2. *Composition of body.*—Evidence of loss; hand on polished surface; breath in cold air; water. Breathing into lime water; result. Presence of nitrogen shown in characteristic smell of burning hair, bones

3. *Fact of waste repaired and growth sustained.*—Examination of ordinary food stuffs. Salt and water in most foods. Potatoes scraped, starch strained off, dried and tested for carbon. Heated, it chars (test for carbon). Albumen. Dried white of egg mixed with soda-lime, and tested for nitrogen.

4. *Chemistry of Food.*—See Special Course in Physiology and Hygiene.

5. *Water.*—Water as a solvent; rain water and spring and river water; drinking water; physical properties of good drinking water; taste of boiled water; sediment in boiling utensils; hardness of water; other inorganic matter in water; danger of leaden pipes for water. Organic matter in water; bacteria in water; microscopic examination of stagnant water; test for organic infected water. Filters; conditions of reliability of filters.

6. *Digestion.*—Its object. A general outlined description of the digestive organs, and their work, by means of diagrams. Importance of mastication. Action of saliva may be taken as an evidence of chemical changes which take place. Experiment as in syllabus of Physiology.

7. *Circulation of Blood.*—Description of course of blood; the heart, arteries and veins. Change of blood during circulation. Its work.

8. *Respiration.*—Fact of respiration noted; description of lungs; and demonstration and mechanism of breathing illustrated by means of diagrams on lungs and windpipe of sheep or rabbit. Advice on proper breathing. Harmfulness of any clothing which prevents full expansion of lungs.

9. *Air.*—Composition of air; carbonic acid; respiration of plants and animals; combustion; noxious gases; escape of gas for lighting; excess or defect of water-vapour. Dust; particles of solids; microbes; description of microbes; their *rôle*; conditions which favour their growth. Ventilation; principle of heated air rising; experiments; natural and artificial. Ventilation incomplete without two openings; good ventilation and draughts; natural ventilating shaft in houses; space required in dwelling houses. Demonstration on simple ventilators. Diagrams, illustrations.

10. *Heating.*—Temperature of body and outer air; necessity of heating; phenomena of combustion; effects and products; what draught in fire means; condition of good draught; heating by open fires and stoves; advantages and disadvantages; the kitchen range; dampers or regulators in stoves. Gas fires; oil stoves; their hygienic value.

11. *Skin.*—Description; sweat glands; sebaceous glands, their functions; necessity for washing skin; soap. Baths and bathing; warm, tepid, and cold bath; suitability of each kind. Evaporation from skin; loss of heat; damp clothes; secondary aids for regulating

heat of body; how they favour action of skin; good conductors, bad absorbents; danger of chill; good absorbents, bad conductors; their value for sick, young, and old. Examination of linen, cotton, and woollen underwear; non-conductors, waterproofs, rubber-shoes. How material, texture, form, and colour can alter hygienic value of clothing. The ideal dress.

12. *Lighting.*—Description of eye; a good light for the eyes; restful colours. Natural light; effect of sun as oxygen-producer in plants; its disinfecting power. Comparison of candle, lamp, and gas light as regards brilliancy and steadiness. Effect of lighting on chemical composition of air in room. Differences of oil, gas, and electricity in this respect. Necessity of ventilation.

Cookery.

Economy.

A consideration of a diet of uncooked food will at once show the advantages of cooking in regard to mastication, to ability to mix foods, to appetite, and to economy of hot food for body. Cooking—the application of heat to food; bread, too near fire, burns; egg, in lukewarm water, never cooks; hence, proper temperature and time: different modes of cooking; advantage of cooking for mastication; cooked and uncooked meat; white of egg coagulates on boiling; bullock's blood also hardens with heat; raw white of eggs soluble in cold water; raw fresh blood mixes with water.

1. *Boiling.*—By putting into (*a*) cold water, and (*b*) boiling water; result. Hard water and soft water in cooking. Slow and fast boiling. Experiment of pudding mixture placed in cold water or boiling water (*a*) in clean cloth, (*b*) floured cloth. Dissolve raw white of egg well beaten up in water, boil and scum, Test scum dried. Soak little juicy meat in cold water, boil, scum, test scum dried. Reason of scumming. Bone treated with hydrochloric acid, boiled; or ordinary bones boiled and cooled. Gelatine; its use. Economic advantage of boiling; weigh meat before and after boiling. Temperature for fish. Concentrated acetic acid poured on white of egg; result. Eggs poached in water and vinegar. Fish rubbed with lemon. Action of salt on raw beef. Piece of meat let stand with salt. Boiling-point of salt water.

2. *Stewing.*—Its principle; aim, temperature, economy. Bain-marie (ordinary stone jar in pot of boiling water): Principle, use, economic advantage.

3. *Frying.*—Temperature of fat compared with water. Bread fried in warm fat, in hot fat. Temperature of frying fat. Use of the thermometer and practical tests for testing temperature of fat. Egg and bread crumb in frying. Water (very little) dropped into hot fat; result. Flouring fish, &c., for frying; and economic advantage of frying.

4. *Roasting.*—Heating by direct radiation; kind of fire needed; advantages and disadvantages from economic point. Temperature; effect of slow fire and quick fire on raw meat.

5. *Baking.*—Hot air chamber; effect on food; advantages and disadvantages of non-escape of air. Ventilation of ovens. Principle of double baking pan. Slow fire and quick fire in baking; economic advantage. Baking powder: its composition. Separation of starch from gluten in wheat. Gluten: its properties in bread making. Cake made of rice flour or corn flour alone. Right heat of oven.

Effect of too great or too small heat. Yeast in bread-making. Examine by microscope; proper heat for fermentation; heavy bread or cake; light bread. Value of beating white of eggs; of mixing butter and flour thoroughly; of kneading yeast bread; of not kneading ordinary paste for tarts.

6. *Grilling* meat over a slow fire or quick fire; economic advantage.

Food Values.

Consideration of foods cooked may follow practical lesson, or hints may be given during lesson. Appearances of good foods can be studied in presence of objects. The advantages of separate treatment of each kind. Explanation of differences of time of cooking in beef, mutton, veal, pork, &c.

(1.) Nutritive properties of meats. General remarks. Mode of cutting up meat may be studied from chart of butcher's "joints." Each piece of meat cooked should be pointed out on chart.

(2.) Eggs.—Weight of good eggs; test in salt water; action of butter rubbed on fresh eggs.

(3.) Milk.—Constituents; action of boiling on milk; sterilizing.

(4.) Peas, beans, and lentils. Their mode of preparation and value as foods.

(5.) Potatoes.—Slice of potato ¼-inch thick held between pupil and light; distribution of water and starch; good potatoes; danger of new potatoes; water changed on boiling. Storing of potatoes.

(6.) Cereals.—Value of ordinary kinds.

(7.) Green and fresh vegetables. The vegetable which appears in *menu* should be considered as regards proper preparation and dietetic value.

Practice.

The following scheme of lessons is intended to illustrate how by choosing seasonable food the different operations of plain cookery may be practised in the first year. The operations of boiling and stewing are intended to be fairly mastered before a new process is introduced. The thermometer should be constantly used to show the differences of temperature required for different methods of cooking the same kind of food, and for the same methods of cooking different kinds of food.

Demonstration is necessary at the beginning of the course; and practice in every new process should be preceded by a short demonstration. Attention is again drawn to the fact, however, that although demonstration is often an essential part of a practice lesson, demonstration is not practice. Demonstrations must be kept within proper limits, and every pupil should have her full practice lesson every kitchen day. Demonstrations in cleaning may be given at a time when the cooking is not pressing. Practice in cleaning is always possible.

A complete and inexpensive *menu*, made up of seasonable and cheap foods, should, if possible, be worked through at every lesson, for, although the attention of the pupils is centred on the mere operation, still in this way they become accustomed to combined foods with a view to their completeness as life supporters, *and to the cost of a* menu *for a given number of persons.* Dishes should be plain.

The cost of materials of every dish, and of every *menu*, should be considered; and the teacher must constantly call attention to the economic value of the various dishes.

The food which is to be cooked should be examined and the qualities of good food discussed; the advantages of cooking the particular food in the way it is being done are to be made clear.

A chart of animals which supply butcher's meat should be hung in the class-room, and parts of meat pointed out.

Notebooks should be kept by pupils, and should be corrected regularly by the teacher.

SCHEME OF COOKERY AND CLEANING.

First Term: October—December.

1. Lighting kitchen range.
Boiled and poached eggs.
Meat boiled by placing in cold water (stock).
Bones boiled.
Coagulation of white of egg by heat and loss of flavour in meat must be noted. Liquid from bones cooled and examined.
Plate cleaned and Pots washed and dried.

2. Potage: made with meat or bones.
White sauce for mutton.
Boiled potatoes.
Boiled mutton.
Explanation and results of different methods of boiling noted.
Washing knives, spoons, &c.

3. Onion soup.
Boiled bacon.
Boiled cabbage.
Steamed potatoes.
Sweeping of kitchen; replacing brushes, &c.

4. Celery soup.
Stewed beefsteak.
Stewed potatoes; spinach.
Boiled pudding.
Dusting.

5. Pea soup.
Boiled fish.
Mashed potatoes.
Boiled rice and prunes.
Scrubbing of tables in white wood.

6. Julienne soup
Hashed mutton or beef heated *à bain marie.*
Potatoes mashed and baked.
Stewed turnips or onions.
Custard heated *à bain marie.*
Cleaning of painted wood; cleaning of varnished wood.

Second Term: January—Easter.

1. Carrot soup.
Fried beefsteak.
Fried potatoes (chips).
Brussels sprouts.
Stewed apples.
Fat clarified—Cleaning of glasses, decanters, bottles.

2. Haricot soup.
   Fried fish.
   Croquettes of potatoes
   Omelet.
   Cleaning silver plate.]

3. Red cabbage soup.
   Roast mutton.
   Haricot beans.
   Potatoes boiled and fried.
   Pancakes.
   Cleaning knives, forks, &c.

4. Turnip soup.
   Roast pork.
   Apple sauce.
   Red cabbage.
   Cleaning zinc.

5. Green soup.
   Baked fish.
   Potatoes with parsley sauce.
   Blanc mange.
   Cleaning copper.

6. Leek soup.
   Roast beef.
   Roast potatoes.
   Baked milk pudding.
   Cleaning tins.

Third Term: Easter—Midsummer.

1. Rice soup.
   Grilled chops, roast potatoes.
   Salad.
   Mayonnaise sauce.
   Cake—made with baking powder.

2. Spring soup.
   Roast lamb.
   Mint sauce.
   Potato pie.

3. Cabbage soup.
   Veal cutlets or roast veal.
   Salad.
   Roast potatoes.
   Madeira cake.

4. White soup.
   Boiled fowl.
   Boiled potatoes.
   Cauliflower.
   Tart made with short crust

5. Green soup.
   Grilled fish.
   Roast potatoes.
   Asparagus.
   Boiled jam roll

6. Lentil soup.
Fish croquettes.
Potatoes with herbs.
Mould of vanilla cream.

HOUSEHOLD KNOWLEDGE.

Cleaning and Care of Utensils, &c.

1. Principle stains on kitchen utensils; grease, insoluble in water Soap; heat small pieces of mutton suet in solution of caustic potash in test tube, *heat to boiling-point*, add salt, examine result. Soda ammonia, and chalk. Soluble and insoluble soaps.

2. *Rust.*—Its prevention; galvanised iron.

3. Action of acids on zinc and copper and brass; dangers of these metals; use of vinegar in cleaning. Stains on silver; stain from eggs, how removed. Mechanical action in cleaning, of whiting, emery powder, sand-paper, sand, and of cinders. Cleaning of knives. Danger of cleaning bottles with shot. Black-lead and turpentine: their action in cleaning range.

4. Consideration of action of different metals under heat, lead, tin, iron, &c., will give at once hints as to their advantage in the kitchen, as well as to the care to be expended on them.

5. Kinds of brushes and cloths that should be used; their care.

Heating.

Heating by convection and radiation; loss in ordinary chimneys; economic and wasteful grate. Description of different kitchen ranges; how they are set and cleaned. Meaning of slacking a fire, and how it is done. Different fuels; economy of fuel; the coal that is most economical.

Practice how to light and keep down a fire.

Clothing.

1. *Choice and selection of clothes*; good taste in clothing; fitness, colour, and fashion. Linen and cotton examined under microscope; treated with drop of oil (olive); result noted. Economic value of linen and cotton; comparative facility of removing stains Wool and silk compared. Shoddy; cheapness and durability. Economic colours; economic form of clothes, and best wearing textures.

2. *Care of clothes*: underclothing, linen not drawn together before washing, is torn. Outer clothes; brushing; removal of mud and grease stains. Solvent power of ammonia, turpentine, benzine, naphtha, and alcohol. Reason for rubbing stain with flannel, and reason of absorbent being under stain where rubbed. *Practise* removing stains from clothes.

3. Advantages and disadvantages of a small quantity, or of a large quantity, of linen and clothes.

Lighting

Lighting: most economical light, sunlight. Care of candles; candlesticks. Oil lamps; paraffin; dangers of impure paraffin. A good lamp; devices for complete combustion; glass, burner, air chamber, &c. "Lampe belge," two air currents. Inexplosive lamp.

Practise how to clean and light a lamp.

NEEDLEWORK.

I.—*Sewing.*

1. Plain sewing.—A demonstration lesson by means of chart or other approved apparatus for teaching sewing. Such method may seem unnecessary with girls of this age, but chart is used merely to help explanation, which should last only a few minutes. Pupils can then work independently under direction of teacher.

2. Samples of stitches:—(1.) All operations of plain sewing, as hemming, felling, running, &c. (2.) Two patches. (3.) Buttonholes, buttons. Samples should be one foot wide, one yard long. Stitches should be done on width. Calico or linen undressed and not too fine.

3. Darning on coarse linen or woollen stuff.

4. Lesson in use of sewing-machine should be given early in term, and all pupils at end of term should know how to fill bobbin, shuttle, and needle, and regulate size of stitches.

II.—*Measuring and Pattern Drawing.*

The system of pattern drawing employed should be one that depends on the ruler, tape-measure and chalk alone. The pattern should be drawn by the teacher full size on board, and simultaneously by pupils, full size on pattern paper. Patterns cut out in paper and material. Patterns reduced to scale in exercise books, and explanation of figures written out on opposite page by pupils.

The following patterns should be worked in class:—Two patterns chemise; two patterns knickers. Pattern ordinary blouse and sleeve for same.

NOTE.—In drawing patterns for dresses, it is well at first to take measurements from the bust, and to use the bust as object during lesson.

III.—*Making.*

1. One garment at least hand-sewn. "Plain" means worked with ordinary plain stitches and not fancy lingerie ones. Articles can be simply trimmed, if desired.

2. Blouse without lining; machine can be used for certain parts, but parts best done by hand should be hand-sewn, as *e.g.*, shoulders closed, sleeves put in, casings, &c.

NOTE.—Pupils of class need not all work one design; variety should be aimed at. Taste as well as economy should be displayed. The pupils' sense of colour and harmony is thus developed, and a knowledge of how design may be varied is gained.

3. *Cost.*—List of materials used; their lengths or quantity, and prices, should form necessary part of work.

SPECIAL COURSE.—FOURTH YEAR SYLLABUS.

As observed in the introduction, this subject is eminently a practical one. A certain number of scientific facts or principles must be known, but Domestic Science proper is the deductive application of these to particular instances. For this reason the Science, so far as it concerns Hygiene or Economy, must deal with incidents which are already familiar to the pupils, or which they are likely to meet with. The observation and experience of the class must constantly be made use of. The circumstances of the pupils must be attended to, and the syllabus should be used with the utmost flexibility. Thus, the general principles of feeding, housing and draining are always the same, but they would not be exemplified in exactly the same way in town and country.

This second part, which deals principally with the choosing of food and houses, and with some notions of illness, must take account of many circumstances that are purely local, while household accounts and management of incomes must deal with incomes suitable to circumstances of the pupils.

In practice a complete *menu* should be aimed at as before. Cleaning of different woods, bronzes, etc., might be added.

Drawing should be combined with the needlework. It will serve to increase the interest of the pupils in their work, and at the same time give them a better taste for arrangement.

PHYSIOLOGY AND HYGIENE.

FOODS.—1. Their nutritive qualities. Necessary food stuffs—proteids, carbohydrates, fats, salts, and water. Accessories: condiments and stimulants.

2. Loss from body daily of carbon and nitrogen gives proportion in which these two elements should be taken. Proportion of carbon and nitrogen in proteid. Mixture of proteids and carbons. What is a complete food? Milk as complete food for infants; subsistence diet of adults, of labourer, of growing boys and girls. Result of a diet containing too little nitrogen, carbon, fat, salts, or fresh vegetables. Results of a too great proportion of these elements. Economic value of potato diet, oatmeal, bread, and tea. Table of principal foodstuffs, in amounts of proteids, carbohydrates, and fats. Problems worked out to show justification or reverse of ordinary practice of combining macaroni and cheese, bacon and eggs, pork and beans, eggs and rice, and serving combined bacon and fowl, roast beef and Yorkshire pudding, etc.

3. Problems worked out to show in what proportion one ought to combine two or more foods in order to have a complete food.

4. Values of meat soup and vegetable soups, of brown and white breads.

5. Tea, coffee, and cocoa; their value as food accessories. Value of chicory. Difference between a decoction and an infusion.

ALCOHOL.—What it is. Popular fallacies as to its power. Its coagulation of albumen. Effect on nervous system. Effects of abuse of alcohol on individual as regards health, intelligence, and will power. Effects on individual's family.

DIGESTION.—Work of digestion might be given experimentally, as suggested in the Special Course in Physiology and Hygiene (Section II., 2).

For a proper description of the organs of digestion a good chart or model is necessary; the separate organs of some animal, for example a sheep, should, if possible, be shown to the class.

DIGESTIBILITY.—1. Comparative digestibility of foods pointed out in first year.

2. Good nourishment does not consist in what is eaten, but in what is assimilated.

3. Things which alter digestive value of food. Time and regularity of meals Over eating or too long intervals without food,

Badly cooked, badly served, badly seasoned, or badly varied foods. Badly masticated food. Too much or too little fluid. Evil effects of latter.

4. Consideration of the arrangement of the dinner. Value of soup or broth at beginning of meal. Arrangement of courses. Consideration of general practice of serving pork and apple sauce, boiled mutton and caper sauce, etc. Comparative values of tea and coffee as after dinner beverages.

5. Effect of nervous system on digestion: instance effects of fright or worry. Necessity for good humour and relaxation at meal-time.

6. Effect of exercise on digestion: when exercise is especially necessary. Difference in diet of sedentary people and those who have active exercise.

7. Number of meals, and of what each should comparatively consist.

Exercise.—1. Growth of muscle by exercise, increase of respiration, effect on circulation, increase of perspiration, how it affects digestion—instance hunger. Excess of movement—fatigue, strain.

2. Lack of exercise; its effects among healthy well-nourished persons.

3. Rest; change of occupation. Sleep: Hygienic and economic advantages of sleeping at night; how bathing feet in hot water helps sleep. Position of sleeper's head. Amount of sleep necessary for children and others.

Cookery.

Economy.

Food.—Appearance of good meat, flour, potatoes, etc., already known. Time to buy food; when a food is said to be in season; where to keep food, and in what kind of vessels. Ways of preserving food, as (1) exclusion of air, impervious layer, meat dipped for five minutes in boiling water, chops turned on the pan, meat covered with layer of fat; (2) exclusion of germs; meat cut in pieces, heated in vessel, and mouth closed with clean cotton wool; (3) preservatives; salt, sugar, borax, powdered charcoal; and (4) pickling in vinegar, etc.; (5) drying fish and meat, fruit and vegetables; (6) freezing.

Marketing.—Value of fresh and preserved foods. Tinned meats, etc., condensed milk.

Adulteration of Food.—1. What it is. Ordinary adulteration of different foods. Practical tests.

2. Milk.—Its density; amount of cream. The lactometer.

3. Butter.—Iodine, reaction of starch. Melt in tall narrow glass, let cool, water sinks. Butter dissolves easily and quickly in ether; other fats with more difficulty.

4. Lard.—Water test; should be free from water.

5. Eggs.—To know if eggs are fresh, (a) 2 oz. salt in pint of water to see if eggs float; (b) by looking through egg; good egg, clear in middle; bad egg, clear at ends.

6. Wheaten Flour.—Foreign starches seen by microscope. Shake flour with chloroform, flour floats mineral matters sink.

7. Bread.—The properties of good bread. Difference in bread made with sour milk, baking powder yeast, or aerated. White,

household, and brown breads. Tests for presence of alum or of sulphate of copper in bread.

8. Arrowroot.—A jelly of arrowroot looks fresh and stiff after two or three days, other starch jellies turn liquid within 24 hours.

9. Tea.—Mixture of other leaves, mineral substances.

10. Coffee.—If chicory is present it sinks in cold water and colours the water.

11. Cocoa.—Thickens on boiling if starch is present.

12. Beer, Wine, etc.—Adulterations; test for.

NOTE.—A few lessons should be devoted to the feeding of infants and young children, using the following outline as a basis:—

Infants should not be fed artificially, unless it is necessary. Reasons why infants require special food, and why the constituents of their food must be varied at different ages. Dangers of improper food; may be of unsuitable composition, indigestible, or innutritious; may be badly prepared, or stale; may be given in wrong quantities. Construction of feeding bottles; those with tubes should should never be used. Cleansing and care of bottles.

Times of feeding for various ages. Sterilization of milk and other foods; advantages and disadvantages. Suitable dietary in composition and quantity for infants from one to three, three to six, six to nine, and nine to twelve months.

Suitable dietary for children from one to two years.

Diseases of children directly caused by unsuitable food, indigestion and cholera infantum, rickets, scurvy.

Demonstrate the cleaning of feeding bottles and the sterilization of milk.

Practice.

1. The cooking of complete *menus* could be continued in this year and the pupils should now give more attention to the composition of the various dishes and the proper way in which different foods should be combined, in reference to their respective proportions of carbon and nitrogen, their digestibility, &c. The mode of cooking should be well varied in each dinner to show how the cooking of different dishes can be conveniently combined so as to save time. *Menus* should consist of two kinds of meat, or meat and fish, and the price reckoned as before. Several *menus* in which neither fish nor meat appear should be cooked. A few breakfast dishes, as oatmeal, different rissoles, as well as breakfast cakes, should be done. The cooking of food for infants and children might also be given, as well as some invalid cookery.

2. A few lessons on preserving might also find place. Making of bread should also form one at least of the lessons.

3. Invalid Cookery.—Cooling drinks; lemonade, barley water, toast and water, beef-tea, chicken broth, with a knowledge of how they should be flavoured. Gruel, invalid's fish, outlet. Egg-flip, jelly. One or more of these can be made in addition to the dinner.

4. Preserving: Eggs, salting butter, whole fruit in vinegar and syrup, marmalade, one or two jams, jelly. How to keep apples and pears.

HOUSEHOLD KNOWLEDGE.

Care of the House.

The teacher might introduce this part of her subject by reference to different types of housekeepers; she will have an opportunity of pointing out in the various types the many qualities which she has already tried to cultivate in her pupils. She might begin by examining the cases of such housekeepers as the mechanical drudge, one who exhibits no taste and no ingenuity, the type that pays all attention to externals, and the like. The class can then be led to formulate their ideals.

1. Qualities of a good housekeeper. The economic values in a housekeeper of such virtues as order, cleanliness, activity, economy, and foresight, as well as good humour and good taste.

2. Simple laws for letting and renting houses. Liability of landlord and tenant for repairs. Time at which roof and outside of house should be respectively repaired, or painted. The cleaning of windows. Cleaning of inside walls, ceilings, and floors.

3. Value of Cellars.—Their ventilation and dryness.

4. Kitchen.—Complete cleaning of kitchen, how it should be done. Position of kitchen in house; value of a wash kitchen.

5. Bedrooms.—A healthy and economic bed—iron bedstead, hair mattress, light and warm coverings. Its position in room. Disadvantages of bed curtains, tapestries, and plants, and too large carpets. Ordinary furniture of bedroom, its care daily and weekly. Advantages of simplicity and good taste in furniture.

6. Dining-room.—Its use, furniture, and care.

7. Drawing-room.—Its use, furniture, and care.

8. The Yard.—When, and how, to clean it.

9. Drains and water closets: how to disinfect and deodorise.

10. Arrangement of work in ordinary house, according to size. Daily and weekly. The class ought to work this time-table out under direction of teachers.

11. Servants.—Qualities to be looked for in a servant. Hiring them. How they are to be trained. Their material welfare. Relations that should exist between mistress and servant. Dismissing servants. Giving them recommendations.

Note.—In connection with the lessons given under this division, practice lessons in cleaning should be arranged. If the actual objects which form the furniture of a house are not easily accessible, some of the materials which compose them should be at hand, *e.g.*, polished wood mirror, gilded frames, bronzes, marble, &c. Practice in cleaning.

Household Accounts and Expenditure.

1. Necessity of separating household and business or professional accounts.

2. Books.—(1.) Daily book with two columns—one expenses paid, other amounts received. (2.) Weekly or monthly division of items under separate heads. (3.) Tradesmen's pass-books. Advantages and disadvantages of credit and ready money. These accounts should be, as far as possible, real; if the expenses of Economy class are entered at every class, they can be afterwards grouped. A little perseverance is required with the work in class.

3. Disposal of one's income. Arrangement and percentage of each head of expenses.

At this stage an attempt should be made to drive home some guiding directions which have become proverbial, such as saving is earning, hence this subject, *i.e.*, Domestic Economy, is of high industrial value; pay ready money; never anticipate uncertain profits; keep the strictest account of all you save and all you spend; see that nothing is lost.

4. What saving is; how and why one ought to save. Economic value of co-operation, savings banks, insurances, and annuities.

Actual account of working expenses as far as coal, light, food used in kitchen, &c., should be kept by pupils and grouped at end of every month.

Washing.

Necessity of washing. Try to remove stains of grease from napkin by brushing, shaking, &c. Now try alcohol. Need of solvent. Our ordinary solvent.

NOTE.—In this connection pupils should work out in the laboratory some simple experiments, as soap-making, the bleaching power of chlorine, &c.

(1.) Water: hard and soft water; value of rain water; ways of softening hard water.

(2.) Soap: experiment already given.

(3.) Soda: Its properties; solvent powers in cold and hot water; soda in cold water (undissolved); let rest on linen; result. Effect on animal substances—wool and silk.

(4.) Potash: how used in laundry.

(5.) Ammonia: its action on grease; power of saponification.

(6.) Blue: (1) Indigo blue; (2) Prussian blue.

(7.) Chloride of Lime, or Bleaching Powder.—Bleaching action of chlorine can be shown, if not already done in laboratory.

Presence of chlorine demonstrated by treating bleaching powder with dilute sulphuric acid.

(8.) Starch: its composition and effect on linen; effect of heat on it.

(9.) Borax: its use in the laundry.

Ways in which clothes are injured by substances employed; advantages of home washing.

Washing operations.

(1.) Sorting: how clothes should be sorted; reason of sorting.

(2.) Steeping: let raw white of egg dry on two napkins, plunge one in boiling water, throw other in cold water, and mark results. Steeping in cold water; advantage of adding soda; how dissolved.

(3.) Soaping: action of soap; use of soft soap.

(4.) Changing clothes for boiler; manner of wringing.

(5.) Boiling: action on grease; precautions in boiling clothes; length of time to boil.

(6.) Taking clothes from boiler; washing; idea of rubbing in helping solution of stain; practical hints on washing hems, edges and corners of clothes, as well as lace, &c.

(7.) Wringing: when it should be light or strong.

(8.) Bleaching.—Experiments: good bleaching ground.

(9.) Washing.

(10.) Rinsing: why in rain water if possible?

(11.) Rinsing: why in pipe water if possible?

(12.) Blueing: why in pipe water if possible? In what order things are blued. Experiment on new and old linen and calico.

(13.) Starching. } Ways in which clothes are injured during
(14.) Drying. } operations. Advantages of home washing.

Washing of coloured materials.

(1.) Action of soda on coloured things; action of boiling and bleaching; uses of salt, vinegar, and ammonia.

(2.) Removal of stains from linen.—Iron-mould, oxide of iron; action of salts of lemon on this; when iron-mould should be removed. Why? Fruit or wine stains; action of gas from burning sulphur on vegetable tissues to be demonstrated.

(3.) Paraffin washing.—What it is; its advantages and disadvantages. Consideration of some washing machines and wringers. Their use and abuse.

Ironing.

Need of damping clothes, use of wax and borax. General rules for ironing.

NOTE.—The order of operations given here may be varied at the discretion of the teacher; practice lessons are not obligatory—there is, consequently, the greater need for good demonstrations.

The house; its necessity.

Sanitation of House. (1.) Site.—Soil, aspect, situation, elevation. (2.) Building.—Foundation-materials, damp-proof course, walls, roof, projecting eaves, and lead gutters. Cellars: their use.

(*Note.*—In a climate such as ours, the chief points to consider are how a building is made damp-proof.)

Place of kitchen and disposition of rooms. Plans should be drawn by class.

(3.) Drainage and disposal of waste.—Drainage of sub-soil before building. The water closet, its water supply; trap; course of soil pipe, and necessity for its ventilation. Sewer gas; rural system of disposal of refuse. Kitchen and washing sinks, gully traps, necessity for flushing with soda and boiling water. Disposal of kitchen rubbish, removal and destruction.

(4.) Water supply of house.—Amount necessary for domestic purposes. Dangers attending use of well water and pipe water. Cisterns; advantage of cistern for rain water.

(5.) Papering, painting, and furnishing house; æsthetics and hygienic values. Danger of newly-built houses. Walls—comparative hygienic values of paint, whitewash, varnished paper, and ordinary paper on walls. Colours of walls. Light and dark colours. Floors: values of tiles and wooden floors; nailed boards; tongued and grooved boards, and parquet floorings; objects of waxing boards. Carpets, linoleums, etc.

(6.) Furniture.—Advisability of nothing that will lessen ventilation or serve as a refuge for dust and microbes. Simplicity best rule. Disposition of furniture as regards light and draughts.

For the proper understanding of many things which arise in the course, of a few lessons should be given on:

1. *Microbes.*—Some developed on gelatine should be shown under microscope. What they are, their medium, their *rôle* in (*a*) infection, (*b*) putrefaction, (*c*) fermentation. Ways of destroying them or preventing their multiplication. How food and water can carry them.

(*a*.) Disease in source or animals from which food was obtained.

(*b*.) Absorption from air; meat putrefies easily in bad air, milk turns sour.

(*c*.) Food kept until bad.

2. *Disease*—What it is. Infectious diseases.—Epidemic and contagious. How disease is propagated from one person to another—by water, food, air, contact, etc.

Precautions.—Preventive, *e.g.*, vaccination; isolation; disinfection. Disinfectant, carbolic acid; antiseptic, boracic acid; deodorizer, quick-lime. Difference between deodorizers and disinfectants. Special precautions to be taken in time of epidemic, cooking all food and boiling water, good nourishment and good air. Sicknursing.—How to make patient's bed; washing patient; remove dust from room; make and keep up fire; how to serve patient's food and give medicines. Disinfection of room, clothes, etc.; disinfect linen by adding two tablespoonfuls "Sanitas," eucalyptus, or carbolic acid to water, and steep overnight.

3. *First Aid.*—As given in the Special Course in Physiology and Hygiene, with the following additions—attack of nerves, bleeding from nose, and first symptoms in children's diseases, as croup, measles, whooping-cough, scarlatina, chicken pox, mumps, and ringworm. Precautions to be taken.

Practice for First Aid and Sick Nursing.

Frictions: artificial respiration; making a mustard plaster; making a poultice; simple bandages and bandaging; way to make an emetic. Class should be shown to make up a simple cupboard for home treatment.

NEEDLEWORK.

I.—*Measuring and Pattern Drawing.*

The pupils at this stage should be able to take measurements easily and quickly.

(1.) Pattern for bodice for adult—two or three side piece and bias darts. Sleeves for same.

(2.) Pattern skirt or underskirt.

Patterns cut out in paper and material.

Note.—The busts must be used as objects during these lessons.

II.—*Making.*

(1.) Bodice lining for adult. Lining only need be finished, but sleeves, bones, hooks and eyes, &c., should be put in.

(2.) Simple skirt or underskirt.

All work should be fitted by pupils themselves after a general demonstration.

III.—*Cost.*

The prices and lengths of materials for garments made should be reckoned as before.

SUGGESTIONS FOR DOMESTIC ECONOMY EQUIPMENT IN DAY SECONDARY SCHOOLS.

Cookery.

As Cookery forms an essential subject of the Domestic Economy course, provision for cooking, in a kitchen or elsewhere, is necessary in all schools adopting the programme. In schools possessing a good kitchen it is desirable that arrangements should be made to utilise it, the instruction to be given at such times as the kitchen can be completely given up for the instruction of the pupils. Such an arrangement will be approved provided there is sufficient accommodation for the number of pupils taught, and for this purpose twenty-five square feet per pupil may be regarded as a minimum.

Washing or Laundry Work.

It must be clearly understood that individual practical work is expected and that demonstration lessons alone are not be regarded as fulfilling this part of the programme. The kitchen may be used for this purpose. For this section of the work some special equipment will in general have to be provided, so that accommodation for at least one half of the pupils in the class may be given. Wooden troughs for washing, 3 feet by 1 foot 6 inches, by 1 foot 2 inches deep, will be found suitable; sufficient table space for ironing and making up is also required.

Home Sewing.

It will, in general, be most convenient to the school authorities and to the pupils that this work should be done in an ordinary classroom, or in the drawing classroom. The usual straight school desks are unsuitable, and unless single desks are available, chairs and tables should be provided. This subject is one in which the arrangements for the physical comfort of the pupils are most important, in regard to position in sitting and to the light available. These matters should receive special attention, and the Department's Inspectors will be instructed to report upon unsuitable conditions, in which case the school grant may be reduced.

Special Composite Domestic Economy Room.

In schools which do not possess a suitable kitchen, or which are unable to give it up completely, as required for the instruction of the pupils, it will be necessary to provide a Domestic Economy room, which should be composite, so that all the instruction required under the Domestic Economy Syllabus may be accomplished in it. Advice and suggested plans for the suitable arrangement of rooms will be given by the Department's Inspectors upon application to the Department. The following equipment is regarded as a minimum in such a room :—

Cooking stove or range,

One sink, at least 2 feet 6 inches by 1 foot 11 inches, by 1 foot deep, with drainage boards,

One cupboard or press for materials,

Dresser or cupboard for utensils,

Cupboard or press for sewing work,

Blackboard,

Shelves with hooks for utensils,

Deal tables, solidly constructed, 2 feet wide and 2 feet 9 inches high, allowing 2 feet of length per pupil.

Such a room should be a model in respect of neatness, and pupils should be thoroughly acquainted with the arrangement of the utensils and materials. A suitable room for a class of sixteen girls would be 600 square feet, *i.e.*, 20 feet wide by 30 feet long, by 13 feet high. A recess for scullery purposes may be provided if accommodation is available. Hats, cloaks, &c., must be provided for outside this room.

The ventilation of such a room will require special attention when cookery is in progress, and the temperature should not be allowed to rise above 70° Fahrenheit. Pupils should themselves be made acquainted with the means of ventilating the room, and should be capable of attending to it without the teacher's instructions.

SUGGESTED LIST OF APPARATUS.

NOTE.—This list is drawn up for eight pupils only—four groups of two. For larger numbers the utensils must be added to.

Fixtures and Furniture :

Cooking stove or range.
Sink, at least 2 feet 6 inches by 1 foot 11 inches, by 1 foot deep, with drainage boards.
Cupboard or press for materials.
Dresser or cupboard for utensils.
Cupboard or press for sewing work.
Blackboard, at least 3 feet 6 inches by 3 feet.
Shelves, with hooks for utensils.
Deal tables, 2 feet wide by 2 feet 9 inches high, allowing 2 feet of length *at least* per pupil.
Coal bucket, fire-irons and shovel, cinder sifter.

Apparatus :

Balance with weights to read to 28 lbs.
Spring balance to read to 14 lbs.
Clock.
Thermometers—2.
Tall glass for testing milk.
Charts for Physiology.
Charts of modes of cutting up beef.

Utensils :

One pint, half-pint. and quarter-pint measures.
Two iron, tin-lined, round and oval pots.
Three silicated saucepans.
Enamelled-iron saucepan.
Steamer, tin, for large size saucepan.
Two stewpans.
One gridiron.
Two frying-pans.
One omelet pan.
Pot—strong iron—for frying.
Dripping pan (double).
Kettle.
Stone jar.
Four pie dishes.
Tart pans—two large, six small.
Two cake tins.
Fish kettle or key, fitted for saucepan or small pot.
(Roasting jack and meat screen is hardly necessary.)
Eight iron spoons.
Eight forks.
Carving knife and fork.
Eight wooden spoons.
One skimmer.
One wire basket, for frying.
Wire spoon.
Two boards for chopping.
Two meat and suet choppers.
Two colanders (enamelled iron).

Pestle and mortar, stone.
Bread and nutmeg graters.
One dredger for flour, &c.
Two paste-boards.
Four rolling-pins.
Two paste-cutters.
Two pastry brushes.
Water jug, enamelled iron.
Two washing pans, enamelled iron.
One drainer.
Six dishcloths.
Three basins for pastes, milk, &c.
Bin for flour.
Two egg beaters.
Hair sieve.
One spice box, including pepper-box.
Two salt boxes—fine and coarse salt.
Six tin boxes, to hold about 1 lb. or 2 lbs. flour, sugar, &c.
Tea pot.
Coffee pot.
Corkscrew.
Funnel.
Eight cups and saucers.
Eight small plates; eight large plates.

Utensils, &c., for cleaning.

Two zinc buckets.
Six house-cloths.
Hair sweeping-brush.
Carpet sweeper or broom.
Hand brush; dust pan.
Two scrubbing-brushes.
Feather.
Six dusters.
Two black-lead brushes.
Brush for lamp.
Two boot brushes.
One clothes brush.
Two skins, chamois.
One sponge.

Needlework:

Bust of girl and adult for every two pupils.
One sewing-machine; two flattening irons.
Large cupboard for work. Special tables with drawers, or lids that can be raised, are useful.
Tapes, rulers, paper, undressed calico for cutting patterns.

Given under our Common Seal this 19th day of June, 1906.

Present at Board Meeting when Seal was affixed, L. S.

T. J. Bellingham Brady, } *Assistant*
Swift Paine Johnston, } *Commissioners.*

WE, The Lords Justices General and General Governors of Ireland, do hereby approve of the foregoing Rules and Schedule.

(Signed), S. WALKER, *C.*
W. M. JOHNSON.

Dated this 19th day of June, 1906.